Technical Manual for
Stabilized Assay Meter
Model SAM-2

eberline

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TABLE OF CONTENTS

Section Page

I GENERAL

Purpose and Description 1
Specifications 1

II OPERATION

Description of Controls and Connectors 3
Preparation for Use 4
Operation Check 5
Operating the Instrument 5
Practical Considerations of Counting Random Events (Radioactivity) 6

III THEORY OF OPERATION

General 9
Functional Theory 9

IV MAINTENANCE

Disassembly and Reassembly 13
Preventive Maintenance 13
Calibration 13
Troubleshooting 14

V PARTS LIST 15

VI DIAGRAMS 20

VII APPENDIX

Detectors, RD-19, RD-20, RD-21, RD-22
Shield for RD-19

LIST OF ILLUSTRATIONS

Figure Page

1-1 Stabilized Assay Meter, Model SAM-2 ii
2-1 Model SAM-2, Rear View 3
2-2 Model SAM-2, Interior View 4
2-3 Typical Pulse Height Spectrum vs. Threshold Setting 6
3-1 System Block Diagram 8
3-2 Pulse Timing in Discriminator Circuit 10
3-3 Counting Patterns for 7490 and 7492 11
3-4 Logic States in Timer Control 12
6-1 General Schematic, Model SAM-2, Sheet 1 of 2 20
6-1 General Schematic, Model SAM-2, Sheet 2 of 2 21
6-2 Component Layout of High Voltage Board 22
6-3 Component Layout of Amplifier-Discriminator Board. 22
6-4 Component Layout of Scaler Board 23
6-5 Component Layout of Timer Board 23
6-6 Component Layout of Stabilizer Board 24
6-7 Component Layout of Count Rate Board 24

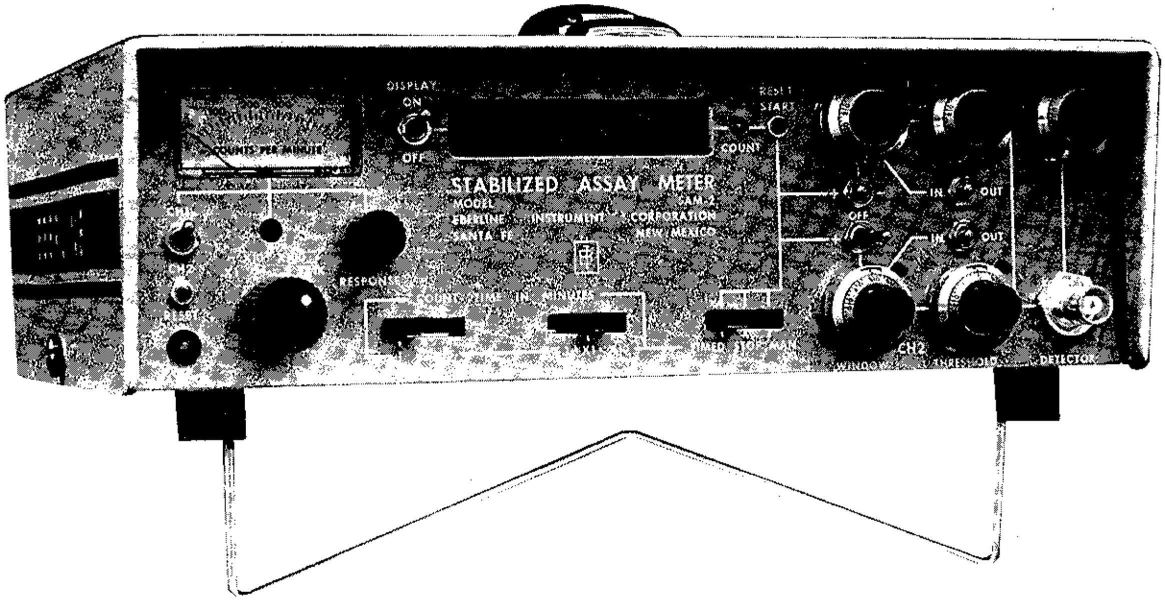

Figure 1-1. Stabilized Assay Meter, Model SAM-2

SECTION I
GENERAL

A. PURPOSE AND DESCRIPTION

The SAM-2 is a compact, lightweight and economical gamma spectrometer which is stabilized to correct automatically for gain changes caused by environmental conditions, component aging, etc. It provides the user a dual channel analyzer with scaler and ratemeter readout of either channel or scaler readout of the sum or difference of the two channels. The instrument may be powered either from the AC line or an optional external battery pack.

Stabilization is obtained from ^{241}Am* doping in the detector scintillation crystal, which, in the RD-19, yields pulses of approximately 3 MeV gamma equivalent. These pulses are counted and used to control the high voltage applied to the detector, thereby maintaining constant gain throughout the system. A rear panel switch disables the stabilization circuit so the instrument can be used as a conventional scaler-ratemeter-analyzer with other types of detectors. A front panel high voltage control is provided to match the requirements of detector performance.

The SAM-2/RD-19 combination is optimized for the detection of the 185 KeV gamma emitted by ^{235}U; however, built-in versatility allows usage over a fairly wide range of energies. Other stabilized detectors are available for use with the SAM-2 for different applications.

All circuitry in the SAM-2 is solid state with extensive use of integrated circuits to enhance reliability. The scaler display utilizes light emitting diodes for excellent readability and reliability.

B. SPECIFICATIONS

1. HIGH VOLTAGE: In the stabilized mode, high voltage is controlled to the value necessary for the proper gain. In the nonstabilized mode, high voltage is regulated and adjustable by a front panel control to approximately 2000V no-load and can supply approximately 1700V to a 100 megohm load. A ten turn potentiometer allows a repeatable predetermined voltage setting. Addition of a regulator tube provides voltages to match a particular proportional detector, up to 3 KV. The supply is a plug-in module for ease of maintenance.

2. AMPLIFIER: Charge sensitive input stage followed by a dc coupled amplifier fed back for stability and control. Overall sensitivity adjustable by an internal gain control from 0.3 to 0.9 volts per picocoulomb (approximately 30 to 90 volts per volt equivalent on voltage sensitive input).

3. THRESHOLDS: Adjustable by calibrated 10 turn front panel controls from 0 to 1.0 volt.

4. WINDOWS: Adjustable by calibrated 10 turn front panel controls from 0 to 1.0 volt, always constant above threshold. Window IN-OUT switches provide gross counting by disabling windows.

5. SCALER: Six digit light emitting diode readout. Counting light stays lit when in counting mode. Decade counters and counting gates are plugged in for ease of maintenance. DISPLAY ON-OFF switch permits counting with display off to conserve battery.

6. TIMER: Preset times from 0.1 minute to 50 minutes in a 1, 2, 5 sequence referenced to 60 Hz line frequency yielding an accuracy typically better than 0.05%. All integrated circuits are plugged in for ease of maintenance. The timer has an oscillator for use with battery or 50 Hz line. Can be modified to sync with 50 Hz line. See Section IV, C, 1.

7. PAIRED PULSE RESOLUTION: Approximately 4 microseconds with pulse height 1.2 times the threshold.

8. PULSE HEIGHT RESOLUTION (With RD-19): Typically 15% FWHM at 185 KeV.

9. RESET-START: Resets scaler and timer to zero and starts a timed count.

10. +, OFF, – : Selects additive, subtractive, or non-counting mode for each channel.

11. TIMED-STOP-MAN: Selects counting mode. TIMED position automatically stops count after preset time selected on timer. MAN position counts continuously. STOP position does not count.

12. RATEMETER: Four linear ranges of 500, 5000, 50,000 and 500,000 counts per minute full scale selected by four position rotary switch mounted on the front panel. Meter response time is continuously variable by a front panel control from 1 to 13 seconds (zero to 90% of final reading). A reset switch is provided for resetting the meter reading to zero. Linearity is within ±5% of full scale.

13. CH1, CH2: Selects channel displayed on ratemeter.

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*Approximately 0.027 microcurie.

14. TEMPERATURE: Operational from 32°F to 140°F (0° to 60°C). In the stabilized mode, gain changes are compensated for. In the nonstabilized mode there is less than ±20% change in gain and threshold or window levels. High voltage changes less than ±1%. In either mode the time base change (battery operation only) is less than ±2%.

15. POWER: Line — 115 or 230 ±10% VAC switch selectable. 50/60 Hz, 1/4 amp, 3-wire. Battery — Any battery 8.0 volts minimum, 14 volts maximum at 1.2 amp load (display on), 0.8 amp load (display off). BATT OK light indicates sufficient battery voltage.

16. DIMENSIONS: 4-1/2" H x 9-5/8" D x 10-1/2" W (11.4 x 24.5 x 26.7 cm), including controls.

17. WEIGHT: 7 lbs. (3.2 Kg).

SECTION II
OPERATION

A. DESCRIPTION OF CONTROLS AND CONNECTORS

1. EXTERNAL (See Figures 1-1, 2-1, and 2-2)

a. DETECTOR: Connection to detector: MHV series coaxial.

b. H. V. ADJUST: Ten turn calibrated dial for setting and changing high voltage when operating in unstabilized mode. Functions as a high voltage limit control when in the stabilized mode.

c. THRESHOLD: Ten turn calibrated dials for setting and changing baseline sensitivity for each channel.

d. WINDOW: Ten turn calibrated dials for setting and changing range of pulse heights to be counted for each channel.

e. IN-OUT: Switches to select gross counting (OUT) or PHA (IN) for each channel.

f. +, OFF, – : Switches to select additive, subtractive or non-counting mode for each channel.

g. TIMED-STOP-MAN: Switch to select counting mode.

h. RESET-START: Switch to reset all appropriate circuitry to zero and start a counting sequence.

i. COUNT TIME IN MINUTES: Switches to select desired counting time.

j. RANGE SWITCH: Selects range of rate meter of 500, 5000, 50,000 or 500,000 counts per minute.

k. CH1, CH2: Switch to select which channel is displayed on rate meter.

l. RESET: Returns meter reading rapidly to 0 when depressed.

m. RESPONSE: Controls response time of the meter.

n. POWER: Switch to supply power to instrument (Rear Panel).

o. BATTERY: Connector for plugging in external bat-

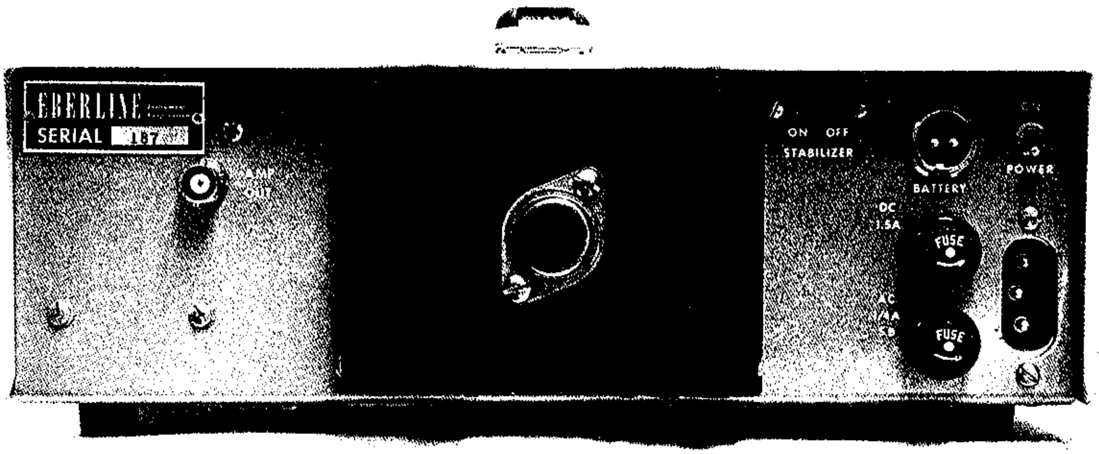


Figure 2-1. Model SAM-2, Rear View

tery (Rear Panel).

p. STABILIZER: Switch selects stabilized or unstabilized operation (Rear Panel).

q. DISPLAY ON-OFF: Switch disables digital display to conserve battery.

r. 115-230: Switch selects 115 or 230 VAC operation (underneath chassis).

s. AMP OUT: BNC connector which provides an output for connection to a multi-channel analyzer.

2. INTERNAL

a. Gain (Channel 1 Amplifier Board): Control for adjusting gain of amplifier.

b. Time (Timer Board): Control to calibrate time base when operating with external battery.

c. Rate Meter Calibration (Rate Meter Board): Controls to calibrate meter reading.

d. Sensitivity (Stabilizer Board): Controls stabilizer set point.

B. PREPARATION FOR USE

1. The instrument should be checked for physical damage.

2. Plug cord into 115 VAC, 60 Hz power source or connect to battery power through BATTERY connector (pin 1 negative, pin 2 positive).

3. Connect detector (stabilized type with internal ^{241}Am source).

4. Set controls as follows:

a. H. V. ADJUST – As set at factory.

b. Both THRESHOLDS – 5.00.

c. Both IN-OUT – OUT

d. STABILIZER – ON

e. DISPLAY – ON

f. TIMED-STOP-MAN – STOP

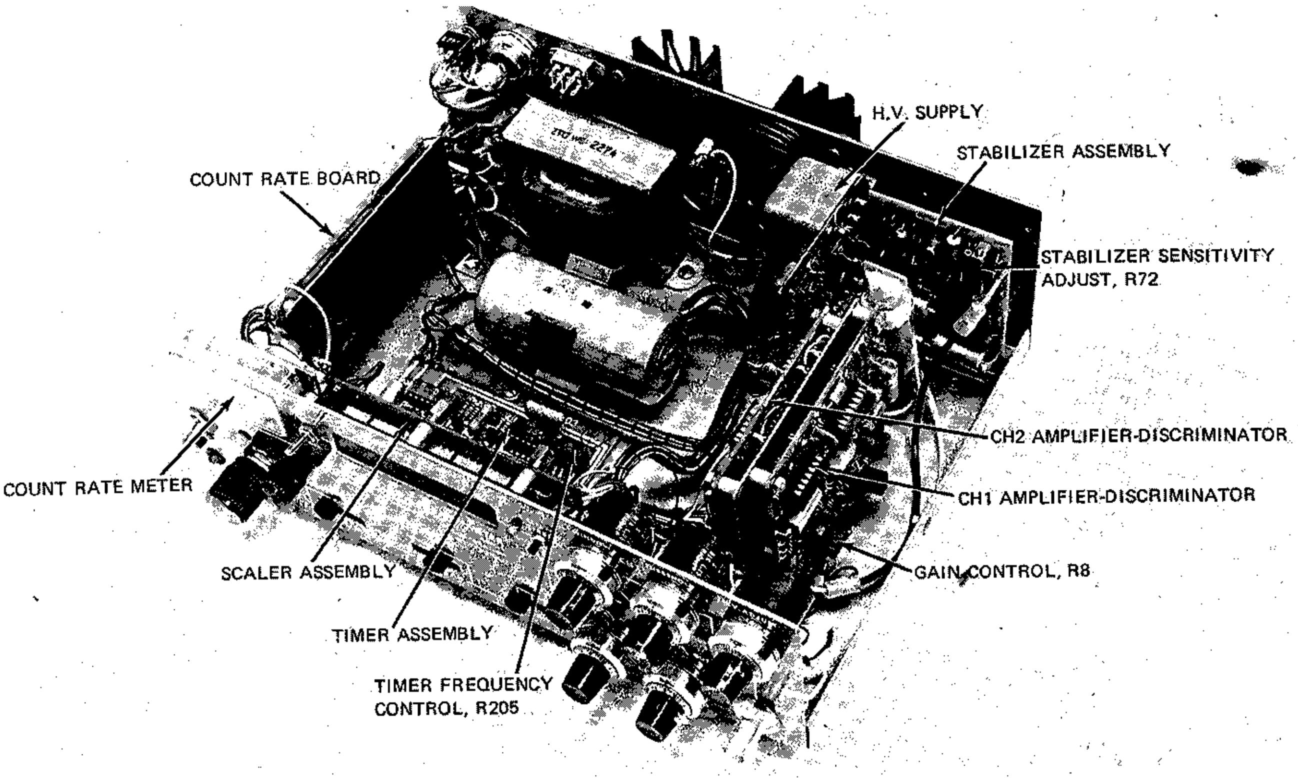

H.V. SUPPLY
STABILIZER ASSEMBLY
COUNT RATE BOARD
STABILIZER SENSITIVITY ADJUST, R72
CH2 AMPLIFIER-DISCRIMINATOR
CH1 AMPLIFIER-DISCRIMINATOR
COUNT RATE METER
GAIN CONTROL, R8
SCALER ASSEMBLY
TIMER ASSEMBLY
TIMER FREQUENCY CONTROL, R205

Figure 2-2. Model SAM-2, Interior View

g. CH1 to +, CH2 to OFF.

5. Turn POWER switch ON and push RESET-START switch. The readouts should be all zeros.

C. OPERATION CHECK

1. Set TIMED-STOP-MAN switch to MAN. Unit should begin to count up.

2. Set TIMED-STOP-MAN switch to TIMED.

3. Set COUNT TIME IN MINUTES switches to 1 and X.1. Press RESET-START switch. Unit should stop counting after 6 seconds, registering 4500–8500 counts (low background).

4. Under conditions 1 thru 3, meter should read 45000 to 85000 counts per minute.

D. OPERATING THE INSTRUMENT

1. ENRICHMENT MEASUREMENTS – GENERAL

The principal gamma activity from ^{235}U is at 185 KeV. In dense, high-Z materials like uranium and its compounds, the 185 KeV gamma does not penetrate far, and a gamma detector essentially samples only the surface of such materials. If an entire sample is viewed by the detector, the 185 KeV count will be proportional to the ^{235}U enrichment and the sample size. If a constant, well-defined area of the sample is viewed by the detector, the 185 KeV count rate will be independent of sample size and shape, and nearly independent of density and compound of uranium.

The true 185 KeV count rate due to ^{235}U is partially obscured, however, mainly by compton scattering of higher energy gammas of ^{238}U down into the 185 KeV region and below. This background must be subtracted from the gross 185 KeV peak signal in order to yield the correct enrichment count rate. The one-half inch thick NaI(T1) crystal in the RD-19 detector provides an optimum signal-to-background ratio for this purpose. The background may be subtracted automatically with the SAM-2.

2. SAM-2/RD-19

The SAM-2/RD-19 is normally shipped calibrated so that the 185 KeV peak of ^{235}U reads maximum with a threshold setting of 5.0 and window setting of 1.0 (20% window). For calibration, refer to Section IV, C, 4. For stabilized operation measuring the 185 KeV peak of ^{235}U, proceed as follows:

a. Operate STABILIZER switch to ON.

b. Set CH1 to +.

c. Set CH2 to – for background subtraction or to OFF.

d. Set CH1 THRESHOLD to 5.0 and CH1 WINDOW to 1.0.

e. Set CH2 THRESHOLD to 7.0 and CH2 WINDOW to 1.3. (CH2 WINDOW is approximate for background subtraction. Exact figure depends on detector-source geometry and calibration. See Section IV, C, 4.)

f. Operate both window switches to IN.

g. Operate mode switches to TIMED, 1.0 minute.

h. Expose the detector to a ^{235}U source.

Depress the RESET-START switch to obtain counts. If necessary, the GAIN control on the channel 1 (outer) amplifier-discriminator board may be adjusted to center the peak at 5.0, CH1 THRESHOLD.

If desired, the window width may be optimized for a particular application by obtaining several curves of counts vs. threshold for different window widths as in Figure 2-3.

NOTE

If channel 2 is used to subtract background for different channel 1 threshold and window settings, the channel 2 controls should also be changed. Refer to calibration, Section IV, C, 4.

3. SAM-2 with RD-20 or RD-21

With either of these detectors, the SAM-2 is calibrated so that 60 KeV corresponds to a threshold setting of 6.0. The apparent peak will be at approximately 5.75 threshold with the window set at 0.5. As with the RD-19, various window widths may be set up at the user's discretion. Channel 2 may be used for background subtraction by setting the CH2 THRESHOLD well above the channel 2 window, and then adjusting the CH2 WINDOW to yield a count rate equal to the background in the channel 1 window.

4. CAUTIONS FOR SUBTRACTIVE MODE

If one channel is to be subtracted from the other, the channels must not be set with adjoining or overlapping windows, or faulty counting may occur due to the possibility that the counters receive up and down counts simultaneously. On SAM-2's equppied with a scaler synchronizer circuit, this is prevented and is not a problem. For most practical applications the synchronizer is not needed, since it is seldom, if ever, necessary to set overlapping or adjoining windows for the two channels, In general, the greater the separation between windows for subtractive operations, the less likely is a counting fault to occur.

5. MINIMUM THRESHOLD SETTING

Do not attempt operation with the threshold control below a setting of 1.0 (one turn). Below this setting, the instrument is so sensitive that noise counts may occur. It should never be an operational requirement to operate below one turn if the SAM-2 and probe combination are set up properly.

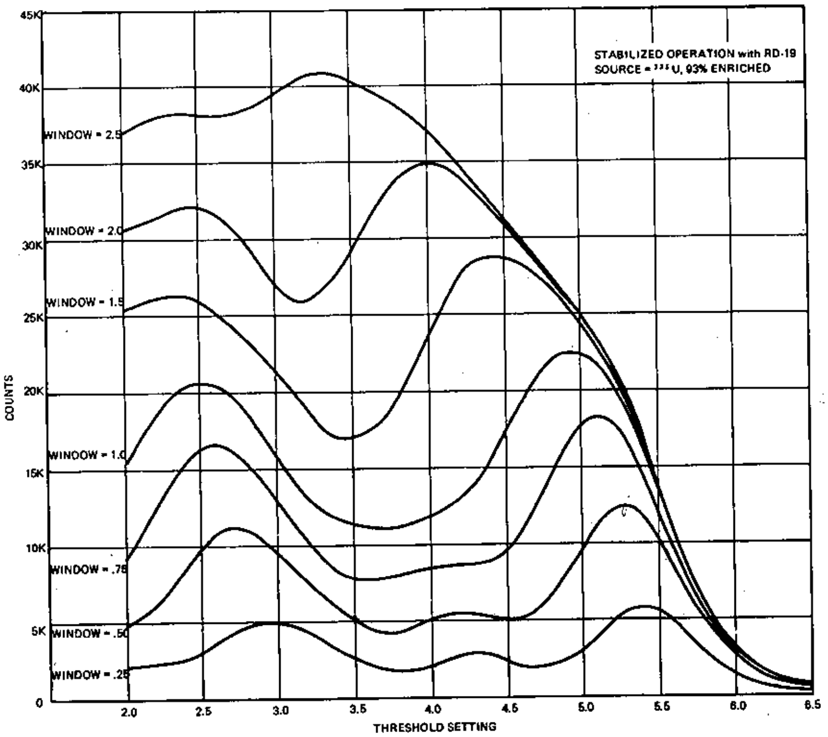


Figure 2-3. Typical Pulse Height Spectrum vs. Threshold Setting

E. PRACTICAL CONSIDERATION OF COUNTING RANDOM EVENTS (RADIOACTIVITY)

1. STATISTICAL DEVIATION

When the total number of counts recorded from a radioactive source is small, the number can be considerably different from the average source value due to statistical deviation.

The radiations from a source are random in nature and the laws of probability apply. From a determined number of counts the following equations can be used to calculate the deviation to be expected from the average source value.

A standard deviation (S.D.) is defined as the square root of the average total number of counts (N_A). The symbol for this is σ. Thus,

$$\text{S.D.} = \sigma = \sqrt{N_A} \qquad \text{Eq. I}$$

Any determination (N) on a sample will be within a certain deviation of the average a fixed percentage of the time, as listed below.

$N = N_A \pm .674\sigma$	50% of the time	Eq. II
$N = N_A \pm \sigma$	68% of the time	Eq. III
$N = N_A \pm 2\sigma$	95% of the time	Eq. IV
$N = N_A \pm 3\sigma$	99.7% of the time	Eq. V

Example A: A 2500 CPM source is counted 100 times for 1 minute each.

$$\text{From Eq. I, S.D.} = \sigma = \sqrt{2500} = 50 \text{ CPM}$$

The distribution of the individual counts will be as follows:

From Eq. II, 50 counts will be within 2500 ±34, or 2466 to 2534 CPM.

From Eq. III, 68 counts will be within 2500 ±50, or 2450 to 2550 CPM.

From Eq. IV, 95 counts will be within 2500 ±100, or 2400 to 2600 CPM.

From Eq. V, nearly all counts will be within 2500 ±150, or 2350 to 2650 CPM.

There is always the possibility that a count will be far away from the average, but this will happen only a small percentage of the time.

2. CONFIDENCE LEVEL

When the average count from a sample is not known and the accuracy of one determination must be specified, a confidence level must be used. Confidence level corresponds to the percentages in Equations II through V. At 50% confidence level, any one determination will be within $\pm.674\sigma$ of the average count. At the 95% confidence level, any one determination will be within $\pm 2\sigma$ of the average count.

Example B: A one minute determination on a sample reads 1747 counts. The standard deviation (σ) is 42. The accuracy of the determination can be specified as follows:

1747 ±28 CPM 50% confidence level or 1747 ±84 CPM 95% confidence level.

The 95% confidence level is in fairly common usage, however any level can be used as long as it is specified.

3. ERROR IN COMBINING TWO DETERMINATIONS

If the background count is comparable to the sample count, considerable error can be had in the solution when the background is subtracted out. The following formula applies:

$$R = R_S - R_B \pm 2\sqrt{\frac{R_S}{T_S} + \frac{R_B}{T_B}} \quad \text{95\% confidence level}$$

R = Net count rate of sample in counts per minute,
R_S = Count rate of sample and background in counts per minute,
R_B = Count rate of background in counts per minute,
T_S = Time that sample and background were counted in minutes,
T_B = Time that background was counted in minutes.

Example C: Background count is 20 counts in 10 minutes, and sample plus background count is 100 counts in 10 minutes. So,

$R_S = 100/10 = 10$ CPM
$R_B = 20/10 = 2$ CPM
$T_S = 10$ Minutes
$T_B = 10$ Minutes

$$R = 10-2 \pm 2\sqrt{\frac{10}{10} + \frac{2}{10}} = 8 \pm 2\sqrt{1.2} = 8 \pm 2.2 \text{ CPM } (8 \pm 27\tfrac{1}{2}\%)$$

at 95% confidence level.

To get the highest accuracy in the minimum amount of time, the sample counting time (T_S) and background counting time (T_B) should be distributed according to the following formula:

$$\frac{T_S}{T_B} = \sqrt{\frac{R_S}{R_B}}$$

4. RESOLVING TIME ERROR

When counting samples with a high count rate, the determination can be in error because of the finite resolving time of the counting system. The resolving time of a counter can be determined by counting two sources of approximately the same value individually and then together and applying the following formula:

$$\tau = \frac{R_1 + R_2 - R_{12}}{2(R_1 R_2)}$$

where:

τ = Resolving time (seconds)
R_1 = Counting rate, source 1 (counts per second)
R_2 = Counting rate, source 2 (counts per second)
R_{12} = Counting rate, source 1 + 2 (counts per second)

When the resolving time is known, an observed count can be corrected by applying the following formula:

$$R = \frac{R_o}{1 - R_o\tau}$$

where:

R = True counting rate (counts per second)
R_o = Observed counting rate (counts per second)
τ = Resolving time (seconds)

NOTE

Due to simplification of the above equations the accuracy of the correction is limited if the correction exceeds about 20%.

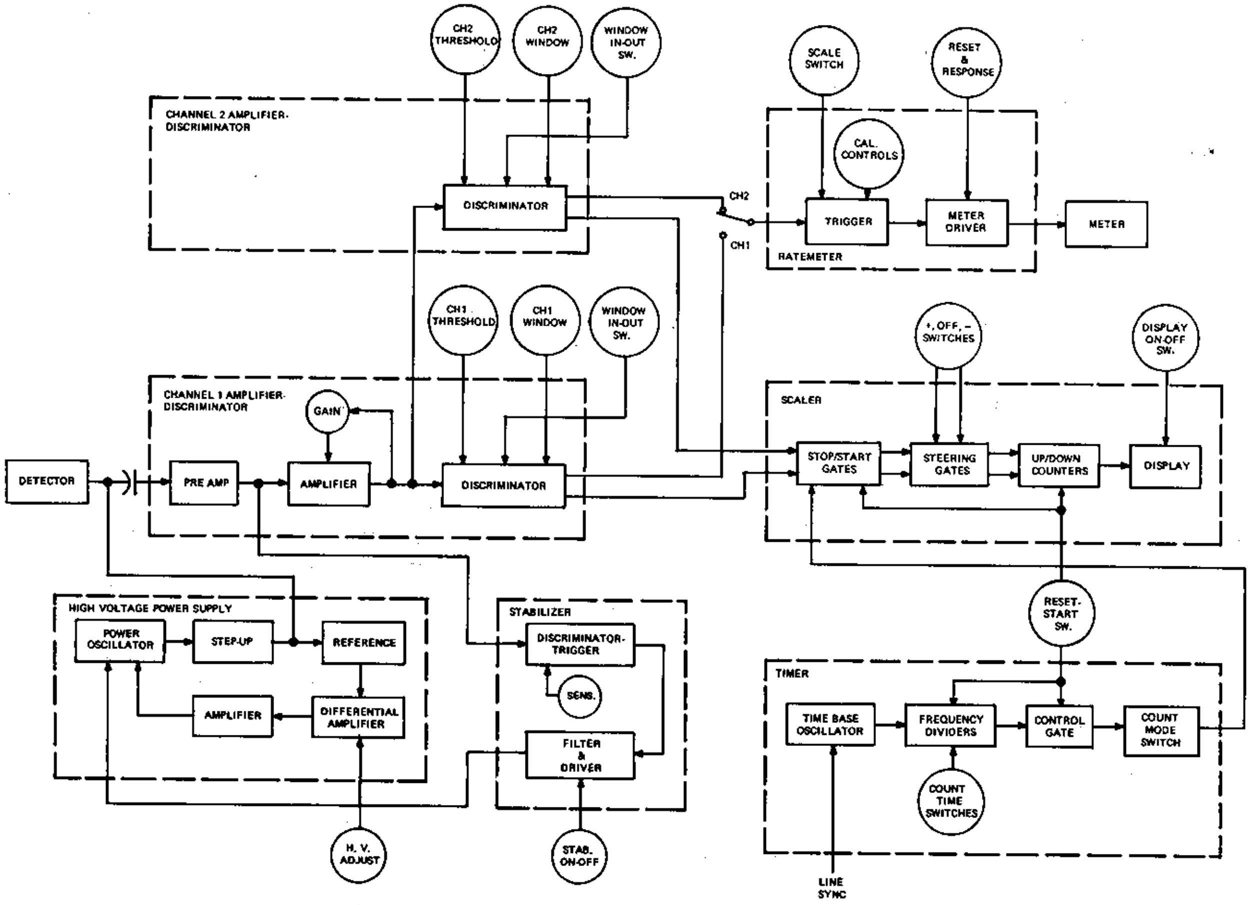


Figure 3-1. System Block Diagram

SECTION III

THEORY OF OPERATION

A. GENERAL (See Figure 3-1)

The high voltage power supply develops high voltage for the detector. When radiation reacts in the detector, negative pulses are generated. The ^{241}Am alpha radiations in the detector crystal provide the pulses which are used to control the high voltage for gain stabilization. These pulses, and the much smaller pulses caused by external gamma radiation of interest, are coupled into a pre-amplifier.

After preamplification, the pulses are applied to the stabilizer circuit and to an adjustable gain amplifier. From the amplifier, the pulses are coupled to the pulse height discriminators, controlled by front panel controls.

The stabilizer controls the high voltage so as to keep the amplitude of the ^{241}Am pulses constant, thereby providing constant gain.

B. FUNCTIONAL THEORY

1. HIGH VOLTAGE SUPPLY

This unit consists of a controlled oscillator (Q101), voltage step-up and rectification (T101), H. V. division (R106, R107, R108, R109, and R112), differential amplifier (Q104, Q105, Q106), amplifier (Q103), and oscillator control (Q102).

The regulation circuit is in balance when the voltages on Q104 and Q105 gates are equal. The high voltage will be a multiple of the voltage on the gates, approximately 630 times. The high voltage is varied by varying the voltage on the reference side (gate Q104) with R402, H. V. ADJUST. As the reference is increased, the differential amplifier is unbalanced, which increases the level of the oscillator and the high voltage output. This puts more current through the H. V. reference resistors, increasing the voltage on the sensing input (Q105 gate) and rebalances the circuit at a higher voltage.

A heavier load tends to lower the high voltage, unbalancing the differential amplifier. This increases the level of the oscillator to maintain the original output.

Changes in power supply voltage are compensated by R110.

The differential amplifier is a matched pair (Q104, Q105) for temperature stability. Q106 is a current source.

The maximum output can be increased by replacing R112 with a regulator tube. The minimum high voltage will then be approximately 100V higher than the regulator tube voltage, and maximum will be approximately 1200V above the regulator tube voltage with an upper limit of approximately 3000V.

The stabilizer circuit controls the conduction of Q102, the oscillator control driver, thereby controlling the high voltage output. The high voltage is determined by the stabilizer or by the H. V. ADJUST, whichever demands the lesser value. For example, if stabilized operation is at 700 volts, but the H. V. ADJUST is set for 1000 volts, the SAM-2 will be operating at 700 volts but will be limited to 1000 volts. The H. V. ADJUST serves as a high voltage limit control during stabilized operation. If the H. V. ADJUST control is set for a value less than that required by the stabilizer, the high voltage will be regulated by the power supply circuitry.

2. STABILIZER

Emitter follower Q50 drives the input side of differential amplifier Q51. R72, the sensitivity control, adjusts the bias so as to vary the input pulse height required for Q51 to switch tunnel diode CR50. Q53 amplifies this signal and drives the monostable multivibrator, Q54 and Q55, which provides a repeatable 33 microsecond pulse to Q56 for each pulse out of Q53. Q56 delivers a smoothed voltage, which is essentially inversely proportional to the ^{241}Am input count rate, to the output stages, Q57 and Q58. If the amplitude of the ^{241}Am pulses tends to decrease, resulting in fewer triggered stabilizer pulses, the voltage out of Q56 will increase. causing Q57 and Q58 to conduct more, raising the high voltage to increase the ^{241}Am pulse heights.

3. AMPLIFIER (Channel 2 amplifier is not used)

Transistors Q1 and Q2 form a charge sensitive preamplifier whose output is proportional to the charge input from the detector. The feedback capacitor C1 determines the sensitivity of this circuit. Constant current source CR2 sets Q1 bias current and, due to its high impedance, provides a very high voltage gain from Q1. Q2 is an emitter follower which provides a low output impedance from the preamplifier.

Transistors Q3 thru Q7 are a dc coupled amplifier with feedback through R10 and R2 to control and stabilize the bias conditions. Gain is controlled by a feedback loop thru R9 to the emitter of Q3. The resistance of R8 (GAIN CONTROL) forms a voltage divider with R9 to determine the gain.

Transistor Q40 is an emitter follower to prevent cross talk between the two channels.

4. PULSE HEIGHT DISCRIMINATORS (CH1 and CH2)

Dual transistor Q8 and Q10 are each a differential amplifier referenced to a bias string consisting of the THRESHOLD and WINDOW controls.

Differential amplifier Q10 is the threshold portion of the discriminator. It is referenced to 2 volts and has the control side bias adjustable from 1.0 to 2.0 volts by the THRESHOLD control. An output pulse will occur only when pulses out of the amplifier exceed the voltage difference between the reference side and the control side of the differential amplifier. For example, if the THRESHOLD control is set at 5.0, control side bias is 1.5 volts. Only pulses larger than 0.5 volt (2.0 – 1.5) will be counted.

Differential amplifier Q8 is the window portion of the discriminator. Its reference side is adjustable from 2.0 to 3.0 volts by the WINDOW control. An output pulse will occur from the window discriminator when any pulse out of the amplifier exceeds the difference between the THRESHOLD control setting and the WINDOW control setting. For example, if WINDOW and THRESHOLD controls were set at 5.0, control side bias is 1.5V and reference side bias is 2.5V. With these conditions, all pulses above 1.0 volt will give an output pulse from the window discriminator.

Transistors Q9 and Q11 are current sources to fix the current through the differential amplifier for stability. Tunnel diodes CR3 and CR4 provide fast and positive switching.

A pulse on the input of the differential amplifiers that exceeds both the threshold level and the window level has a finite time within the WINDOW. (See Figure 3-2.) The pulse width out of the threshold differential amplifier extends from the time the input pulse exceeds the threshold setting (t_1) until it falls below the threshold setting (t_4). Likewise, the pulse out of the window differential amplifier extends from t_2 to t_3. Since an output from the window differential amplifier has to cancel the threshold pulse, and it occurs at a later time, both flip-flops in A1 are connected as trailing-edge triggers. Therefore, at the flip-flop outputs, the window pulse always occurs first (t_3 vs t_4). After a time determined by the time constant of R33 and C9, Q15 turns on, thus resetting both flip-flops (t_5).

If the threshold level only is exceeded, no window pulse occurs to cancel the threshold pulse and it produces a signal on A2 gate output. If the window pulse occurs, the gate is disabled and no output from the gate occurs. The window flip-flops can be disabled for gross counting by S402 (CH1) or S403 (CH2).

5. TIMER

Integrated circuit A201 is connected as an oscillator whose frequency is adjustable by R205 and is set for 60 Hz. When the instrument is powered by the AC line, the oscillator is synchronized to line frequency via Q201.

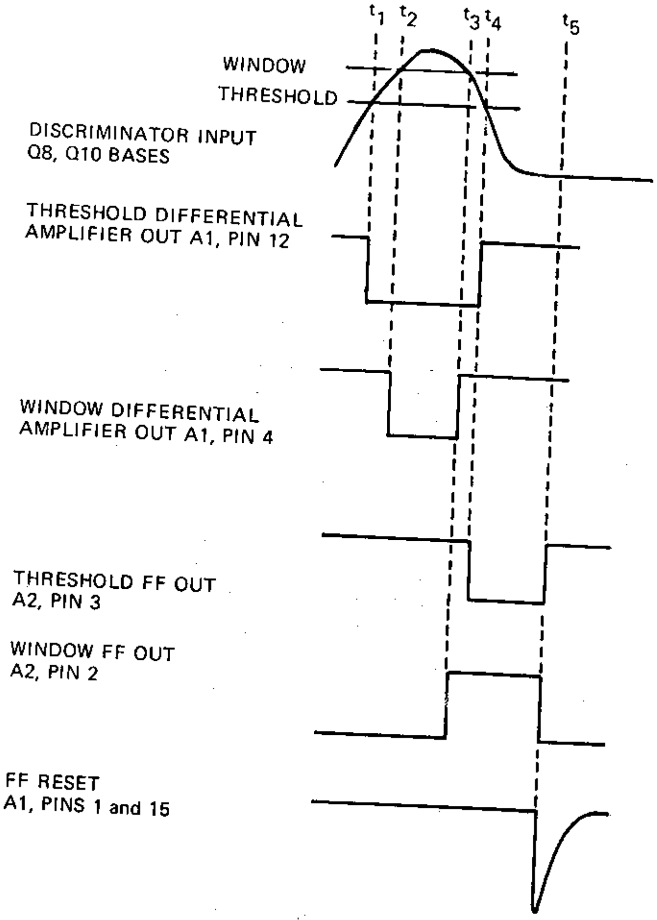


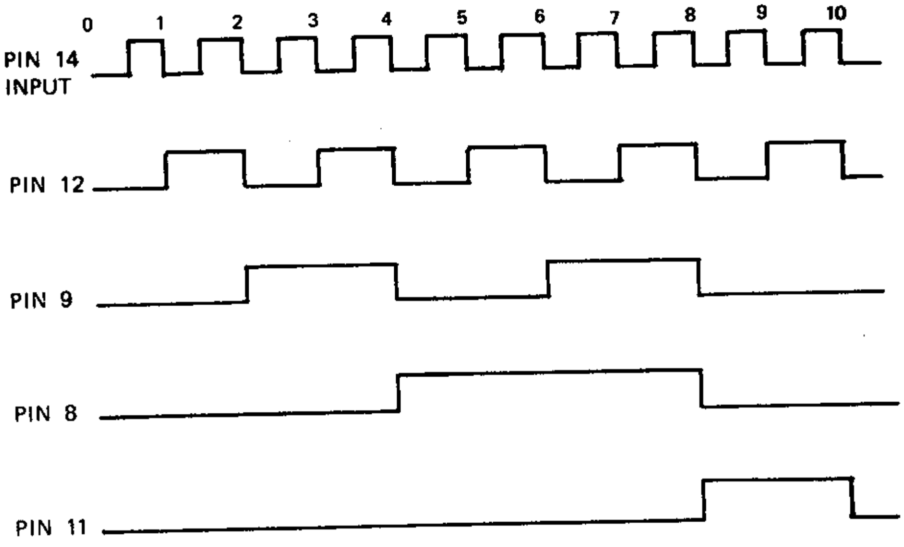
Figure 3-2. Pulse Timing in Discriminator Circuit

Integrated circuits A202 and A203 are connected for divide-by-six countdowns reducing the frequency at A203 output (pin 8) to 100 pulses per minute. A204, A205 and A206 are divide-by-ten countdowns so the frequency at S201 wiper will be 10, 1, or .1 pulses per minute, depending on switch position. A207 and S202 give the option of counting these frequencies down by either 2 or 5. (See Figure 3-3.) The section of A202 that is connected to the wiper of S202 sets the pulse in the right mode to control the gate (A208). The center two gates of A208 form a bi-stable flip-flop. The output of A208 (pin 11) is in a high state when counting and a low state when timed out.

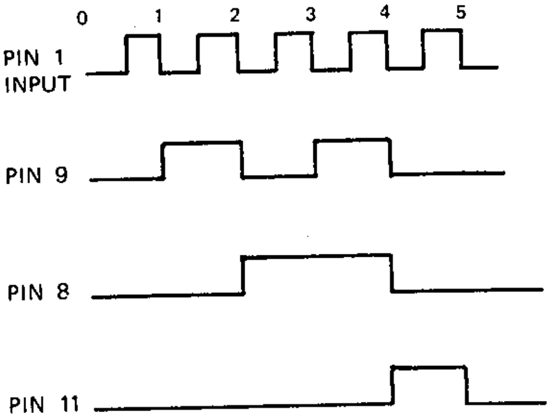
Integrated circuit A208 controls the count gate in the timed position of S203 and controls the reset and start action in the timer. Refer to Figure 3-4 for logic states.

6. SCALER

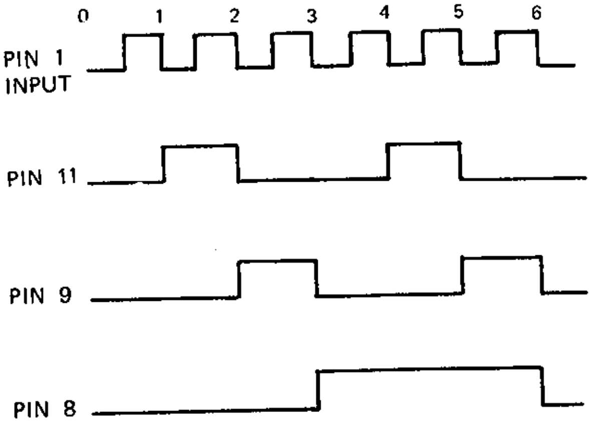
Integrated circuit A313 gates the channel 1 and channel 2 discriminator output pulses to A314, the up/down steering gates, which drive A301–A306, the up/down decade counters. (Refer to Figure 6-1.) If terminal 9 is low (stop condition), gate 1 closes gates 2 and 3 and holds the COUNT



a. 7490 ÷ 10 MODE (A204, A205, A206)



b. 7490 in ÷ 5 MODE (A207)



c. 7492 in ÷ 6 MODE (A202, A203)

Figure 3-3. Counting Patterns for 7490 and 7492

light off. During counting, terminal 9 is high, driving the output of gate 1 low. This turns the COUNT light on and allows gates 2 and 3 to pass the pulses from channel 1 and channel 2. Gate 4 resets the counters upon receipt of a signal from the RESET-START switch.

Gates 5 and 8 of A314 receive channel 1 pulses from gate 2 of A313, and gates 6 and 9 receive channel 2 pulses from A313, gate 3. S410 and S411, the CH1 and CH2 +, OFF, – switches control the states of gates 5, 6, 8, and 9 so as to steer the channel 1 and channel 2 pulses to the count up and count down inputs of the counters, or to block them. If S410 is in the + position and S411 is in the – position, gate 5 will pass the channel 1 pulses through gate 7 to the count up input of A301. Similarly, gate 9 will pass the channel 2 pulses through gate 10 to the count down input of A301. Gate 6 blocks the channel 2 pulses from the count up input and gate 8 blocks the channel 1 pulses from the count down input. If the switch settings are reversed, CH1 –, and CH2 +, 5 and 9 will block while 6 and 8 are open, passing channel 1 pulses to the count down input and channel 2 pulses to the up input. If both switches are in the OFF position, all gates block and no counts are registered. The switches may also be set for both channels to count up or both to count down.

S412, DISPLAY ON-OFF, allows the removal of power from A307–A312, the light emitting diode readouts, in order to conserve battery power. The counters are not affected by this switch, however, so that counting and all other functions operate normally with or without the display lighted.

7. RATEMETER

a. TRIGGER: Integrated circuit A501 is connected to operate as a monostable multivibrator whose pulse width is controlled by the RC time constant between its pins 8 and 6. This time constant is established by the setting of the range switch S405 which selects a particular R and C. The calibration controls from the R for each scale, making the pulse width continuously adjustable for calibration.

b. METER DRIVER: The driver Q502 is normally off so no current flows through the meter. When the trigger is on, Q502 is turned on and current flows. The amount of current is determined by the voltage on the base of Q502 and R510. The length of time that current flows is determined by the pulse width of the trigger. This (current times time) forms a certain charge which is transferred to C506 for each event counted. C506 discharges through the meter, yielding a certain average current dependent on the rate of input pulses. Changing the pulse width of the trigger (i.e., changing scales or calibration pot settings) changes the average current for a given input pulse rate. This allows the meter to read in CPM from the discriminator.

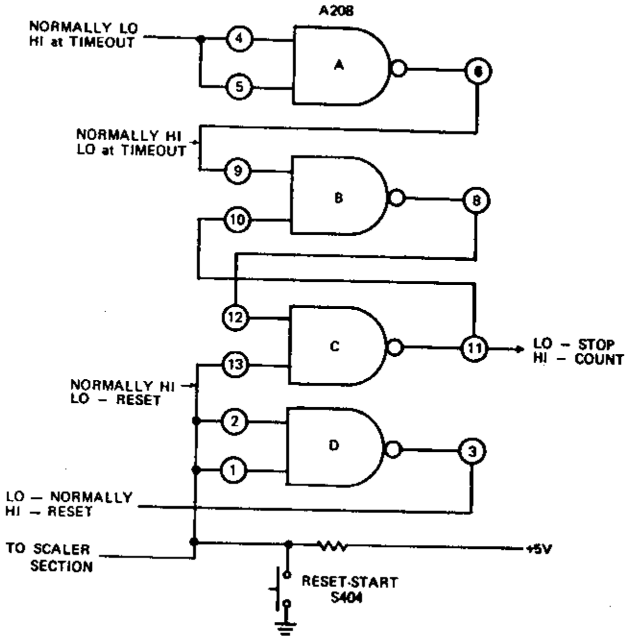


Figure 3-4. Logic States in Timer Control

The response time of the meter is controlled by the RC time constant of C506 and R406, the response control. With R406 set to low resistance, the time constant is fast, and at high resistance it is slow.

8. LOW VOLTAGE SUPPLY

The AC line voltage is stepped down by T401 and rectified by A401. Voltage regulator A402 is a series regulator and supplies +5 volts to the circuitry. External battery connector, J402, is isolated by CR401. Zener diode CR402 limits the voltage to the high voltage power supply to 7.5V.

Switch S408 selects either 115V or 230V line operation.

SECTION IV
MAINTENANCE

A. DISASSEMBLY AND REASSEMBLY

1. To remove cover, remove one 10-32 screw on each side and lift off cover.

CAUTION

Severe shock can occur from the charge on filter capacitor C402. Make sure high voltage has been shorted out by shorting the detector connector center pin to ground.

2. To remove high voltage supply, remove hold-down screw and lift from socket.

3. To remove either amplifier-discriminator board, remove the four 4-40 nuts on the board. Unsolder C403 (CH1) and tilt board away from bracket for access to bottom side.

4. To remove timer board, remove the four 4-40 screws that hold the timer board in place. Slide the timer board back and tilt to center of chassis for access to the bottom of the board.

5. To remove scaler board, remove the three nuts that hold the scaler board to the chassis. Swing the board toward the center of the chassis for access to the front side of the board.

6. To remove rate meter board, remove the three mounting nuts and lift the board outward.

7. To remove the stabilizer board, remove the two rear mounting screws and lift board.

8. To reassemble, reverse procedures.

B. PREVENTIVE MAINTENANCE

1. Keep the instrument clean and dry.

2. The SAM-2 has no components that require scheduled maintenance.

C. CALIBRATION

1. TIMER

The timer need not be calibrated unless the instrument is to be used with an external battery or from a 50 Hz power source with the timer not synchronized with the line frequency. With an external battery connected, or terminal 6 of the timer board disconnected, which defeats the line synchronization, two methods may be used to calibrate.

a. Using an oscilloscope and monitoring at terminal 7 of the timer board, adjust R205 for 60 Hz (16-2/3 milliseconds period).

b. Connect a pulse generator with an accurate time base (such as EIC Model MP-1) to the detector connector. Remove the high voltage power supply if the pulse generator could be damaged by the high voltage. This is not necessary with the MP-1. Preset a time and adjust R205 for the correct reading on the scaler.

The timer may be modified to provide the correct time base while synchronized with a 50 Hz line frequency. Replace A203, I. C. type 7492, with a type 7490 and check that pins 2 and 3 of the I. C. socket are connected to ground. This change makes A203 a divide by 5 counter instead of a divide by 6 type. R205 should then be adjusted for 50 Hz (20 millisecond period) at terminal 7 if occasional battery operation is contemplated.

2. COUNT RATE METER

Using a pulse generator with a known time base, such as EIC Model MP-1, or a variable pulse generator with an oscilloscope, set for 400 CPM input to the SAM-2.

With the range switch on X1, adjust X1 calibration pot on the rate meter board for a reading of 400 on the meter.

Repeat with 4000, 40,000, and 400,000 CPM on X10, X100, and X1K ranges.

3. AMPLIFIER AND STABILIZER

The stabilizer is set at the factory for an input sensitivity of approximately 1.2 volts. The amplifier gain is then adjusted to maximize the 185 KeV gamma count rate from ^{235}U with a threshold setting of 5.0 (0.5 volt) and the window set at 1.0 (0.1 volt above threshold). Different threshold and window settings may be used, of course, at the user's discretion. (Refer to Figure 2-3.) The stabilizer sensitivity and amplifier gain are related in that if the stabilizer is set for smaller pulse height sensitivity, the high voltage will be reduced as required to produce this smaller pulse height from the ^{241}Am source, and all other pulses will be reduced in amplitude proportionately, as if the amplifier gain had been decreased.

When set up for use with RD-19, the factory settings optimize operation of the instrument based on the relationship of the ^{235}U 185 KeV gamma energy to the gamma equivalent energy of the ^{241}Am alpha radiations, which is 3 to 4 MeV in the RD-19. With the stabilizer set for 1.2 volts, the 3 MeV pulses will be 1.2 volts at the preamp output and the 185 KeV gammas will be 74 millivolts. In order for the 74 millivolt pulses to trigger the threshold discriminator, a gain of 6.8 is required of the amplifier. If the stabilizer is set for 1.0 volt, the 185 KeV gammas will produce 62 millivolt pulses. An amplifier gain of 8.1 would then be needed to produce 0.5 volt pulses at the discriminator. If the gamma equivalent energy of the ^{241}Am is 4 MeV, the 185 KeV pulses will be proportionately smaller, and the amplifier gain required to increase them to .5 volt will be proportionately greater. The threshold setting of 5.0 is arbitrary but chosen because it is the center of the threshold control.

The SAM-2/RD-20 and SAM-2/RD-21 combinations are set up somewhat differently than the SAM-2/RD-19, because the gamma equivalent energy of the ^{241}Am stabilization source is approximately 1 MeV in these detectors, which are intended for investigation of gamma energies well below 100 KeV, such as the 60 KeV and 17 KeV emissions of ^{241}Am and ^{239}Pu.

With the stabilizer sensitivity set for 1.2 volts, the 1 MeV pulses will be 1.2 volts at the preamp output, and the 60 KeV gammas will be 72 millivolts. If the threshold discriminator is set at 6.0 (0.6V), an amplifier gain of 8.3 is required to raise the 72 mV pulses to this level. 17 KeV pulses will then trigger the threshold discriminator at a setting of 1.7, and the THRESHOLD control, X10, corresponds to the radiation energy in KeV.

4. SAM-2/RD-19, ^{235}U ENRICHMENT CALIBRATION

In order for this calibration to be valid as a basis for enrichment measurements, the following conditions must be met:

a. The ^{235}U source(s) must be of known enrichment and essentially infinitely thick ($>$2.0 mm) for 185 KeV gammas.

b. The detector-to-source geometry; distance, shielding and area of source seen by detector, must be well defined and repeatable.

Expose the detector to the calibration source and adjust the GAIN control on the channel 1 (outer) amplifier discriminator board until the channel 1 peak is obtained with the CH1 THRESHOLD at 5.0 and the CH1 WINDOW at 1.0. Record the peak count rate.

Remove the calibration source and expose the detector, with identical geometry, to a source of depleted uranium (0% enrichment). Record the channel 1 count rate. Set CH2 THRESHOLD to 7.0 and adjust the CH2 WINDOW until the channel 2 count rate is the same as the channel 1 count rate for the depleted source.

Now, with CH1 + and CH2 –, background will be subtracted automatically. Expose the detector to the calibration source again, and obtain a net (CH1 minus CH2) count, which is proportional to the enrichment of the source. Measurement of unknown sources will provide count rates proportional to the source enrichment, subject to conditions a and b.

If a depleted source is not available, two sources of known, but different, enrichment and identical configuration (for identical detector-to-source geometry), may be used to establish the CH2 WINDOW setting for background subtraction and the count rate vs. enrichment relationship:

Obtain gross (CH1 only) counts for each source and plot the counts vs. enrichment on a graph. The line defined by these two points will intersect the ordinate (0% enrichment) at a count rate which must be subtracted from the two source points in order to define the origin based count rate vs. enrichment line. With CH1 + and CH2 –, adjust the CH2 WINDOW until the count rate from either of the calibration sources falls on this new line.

5. CALIBRATION OF SAM-2 WITH RD-20 or RD-21

Expose the detector to a source of 60 KeV gammas and adjust the channel 1 GAIN control until the channel 1 peak reading is obtained with the CH1 THRESHOLD at 5.75 and CH1 WINDOW at 0.5. Remove the source and obtain a count of channel 1 background at these settings. Set the CH2 THRESHOLD to 10.0 and adjust the CH2 WINDOW until the same count is obtained in channel 2. Set CH1 + and CH2 –, and obtain a count with the calibration source. This count represents the net count of the source with background subtracted.

D. TROUBLESHOOTING

Typical voltages and waveforms are given on the schematic. Use of the schematic, along with the Theory of Operation section and its waveforms and diagrams, should help to isolate and pinpoint problems. Component locations are shown in Section VI.

Voltages, except the high voltage, are measured with a 20,000 ohms per volt, or greater, voltmeter. An electrostatic voltmeter should be used to measure the high voltage.

If an electrostatic voltmeter is not available for measuring high voltage, the voltmeter used for the other voltages may be used to give an indication of high voltage. It must be remembered, however, that this is only an indication.

REF DESIG	PART	DESCRIPTION	MFR AND PART NO
2. CHASSIS (Continued)			
CR401	Diode		Motorola 1N4720
CR402	Diode, Zener	7.5V	Motorola 1N5343A
CR403	Diode, Zener	6.8V	1N5235
DS401	Diode	Light Emitting	Monsanto MV5021
F401	Fuse	1/4A, Slo Blo, 3AG Size	
F402	Fuse	1-1/2A, 3AG Size	
J401	Connector	MHV (Detector)	Amphenol 27025
J402	Connector	2-wire (Battery)	Amphenol 80PC2M
M401	Meter	0-50 ua DC with 10472-B60 Meter Face	Jewell Model 81T
R401	Resistor	33, 3W	Sprague 242E3305
R402	Potentiometer	10K, 10-Turn	Beckman Helipot 7276
R403, R404, R409, R410	Potentiometer	1K, 10-Turn	Beckman Helipot 7276
R405, R411	Resistor	2.2K, ±10%, 1/4W	
R406	Potentiometer	50K	IRC-CTS RV6NAYSD-503A
R408	Resistor	220, ±10%, 1/2W	
S401	Switch	Toggle, DPDT (POWER)	Alco MTA-206N
S402, S403, S409, S412	Switch	Toggle, SPDT	Alco MTA-106D
S404, S406	Switch	Pushbutton, N. O.	Grayhill 39YY2035
S405	Switch	3-Pole, 4-Pos. Rotary	Mallory 3134J
S407	Switch	Slide, DPDT	Continental Wirt Type G126
S408	Switch	Slide, .031 High Screw Driver Slot Knob, imprinted 115-230	C. W. – GF326
S410, S411	Switch	Toggle, 3-Pos., SPDT	Alco MTA-106E
T401	Transformer	7.5V, 3A Secondary	Zenith No. WE 2274
3. AMPLIFIER-DISCRIMINATORS			
A1	Integrated Circuit	Dual JK Flip-Flop	Fairchild U7B9L2459X ICLSA00109? or equivalent
A2	Integrated Circuit	Quad 2 Input NOR Gate, low power, Type 74L02, DIP, 0-70°C	T. I. SN74L02N or equivalent ICLSA00002
C1	Capacitor	4.7 pF, 1000V	Sprague 10TCC-V47
C2	Capacitor	3.3 μF, ±10%, 15V	Kemet K3R3C10 or equiv.
C3	Capacitor	.001 μF, ±10%, 200V	Sprague 192P-10292
C6, C11	Capacitor	120 μF, 10V	Type CS13B
C7, C8	Capacitor	.022 μF, ±10%, 200V	Sprague 192P-22392
C9	Capacitor	150 pF, 100V	CRL DD-151
C40	Capacitor	220 pF, 100V	Aerovox CK12BX221M
C41	Capacitor	.01 μF, 80V	Sprague 192P1039R8

SECTION V
PARTS LIST

REF DESIG	PART	DESCRIPTION	MFR AND PART NO
1. STABILIZER BOARD			
C50	Capacitor	0.1 μF, 10V, Disc Ceramic	Sprague No. HY-360 or equiv.
C51	Capacitor	0.01 μF, 200V	Sprague No. 192P-10392
C53	Capacitor	180 μF, 6V, ±20%, Ta.	CS13 Case Size "C"
C55, C56, C57, C58	Capacitor	330 μF, 6V, ±20%, Ta.	CS13 Case Size "D"
CR50	Tunnel Diode		Type 1N3712
Q50, Q52, Q54, Q55, Q56, Q57, Q58	Transistor	NPN, Silicon	Type 2N4124
Q51	Transistor	Dual NPN	Sprague No. TD101
Q53	Transistor	PNP, Germanium	Type 2N964
R50, R59, R60	Resistor	10K, 10%, 1/4W	
R51	Resistor	2.2K, 10%, 1/4W	
R52	Resistor	750, 5%, 1/4W	
R53	Resistor	470, 10%, 1/4W	
R54	Resistor	220, 10%, 1/4W	
R55, R69	Resistor	1.2K, 5%, 1/4W	
R56	Resistor	910, 5%, 1/4W	
R57	Resistor	1.1K, 5%, 1/4W	
R58, R61, R62, R64	Resistor	4.7K, 10%, 1/4W	
R63	Resistor	1K, 10%, 1/4W	
R65	Resistor	3.6K, 5%, 1/4W	
R66	Resistor	5.1K, 5%, 1/4W	
R67	Resistor	100K, 10%, 1/4W	
R68	Resistor	330, 10%, 1/4W	
R70	Resistor	1 Mego, 10%, 1/4W	
R71	Resistor	3K, 5%, 1/4W	
R72	Potentiometer	1K	Amphenol Type 3800P
R73	Resistor	22, 10%, 1/4W	
R74	Sensistor	680, 1/4W	T. I. Type TM 1/4
2. CHASSIS			
A401		Bridge Rectifier	Varo VH-148
A402		Voltage Regulator, 5V	National LM309K or FSC UGJ7109393
C401	Capacitor	10,000 μF, 15V	Aerovox PRS-1244
C402	Capacitor	0.05 μF, 3.5KV	Capco EBL-1
C403	Capacitor	220 pF, 3KV	CRL DD30-221
C404	Capacitor	0.047 μF, 80V	Sprague 192P4739R8

REF DESIG	PART	DESCRIPTION	MFR AND PART NO
3. AMPLIFIER-DISCRIMINATORS (Continued)			
CR1	Diode		1N4148
CR2	Current Source	0.43 milliamp	Motorola 1N5289
CR3, CR4	Tunnel Diode		GE 1N3712
CR5	Diode		1N34A
Q1	JFET		Motorola 2N5358
Q2, Q4, Q6, Q7, Q9, Q11, Q40 Q15	Transistor	NPN, Silicon	2N4124
Q3, Q5	Transistor	PNP, Silicon	2N4126
Q8, Q10	Transistor	Dual NPN	Sprague TD101
Q12, Q13	Transistor	PNP, Germanium	Motorola 2N964
R1, R16, R17, R28, R29	Resistor	1K, ±10%, 1/4W	
R2	Resistor	2.2 Mego, ±10%, 1/4W	
R3	Resistor	2.7K, ±5%, 1/4W	
R4, R32	Resistor	4.7K, ±10%, 1/4W	
R5	Resistor	3K, ±5%, 1/4W	
R6, R11	Resistor	2.2K, ±5%, 1/4W	
R7	Resistor	120 ohm, ±10%, 1/4W	
R8	Potentiometer	5K	Bourns 3252W-1-502
R9, R10, R21	Resistor	10K, ±10%, 1/4W	
R12	Resistor	1.2K, ±5%, 1/4W	
R13	Resistor	1.5K, ±5%, 1/4W	
R14	Resistor	3.3K, ±5%, 1/4W	
R15	Resistor	6.8K, ±5%, 1/4W	
R18	Resistor	22 ohm, ±10%, 1/4W	
R19, R24	Resistor	220 ohm, ±10%, 1/4W	
R20, R26, R40	Resistor	470 ohm, ±10%, 1/4W	
R22, R25, R41	Resistor	2K, ±5%, 1/4W	
R33	Resistor	16K, ±5%, 1/4W	
R34	Resistor	820 ohm, ±10%, 1/4W	
R36	Resistor	3.9K, ±10%, 1/4W	
4. RATE METER BOARD			
A501	Integrated Circuit	Quad 2 Input NOR Gate	Motorola MC717P
C501	Capacitor	500 pF, 500V	
C502	Capacitor	.33 µF, 10V	Type CS13 Case B
C503	Capacitor	.033 µF, 200V	Sprague 192P 33392
C504	Capacitor	.0033 µF, 200V	Sprague 192P 33292
C505	Capacitor	330 pF, 1KV	
C506	Capacitor	120 µF, 10V	
CR501	Diode		Motorola MZ2361
CR502	Diode		1N34A

REF DESIG	PART	DESCRIPTION	MFR AND PART NO
4. RATE METER BOARD (Continued)			
R501, R511	Resistor	10K, ±10%, 1/4W	
R502, R503, R504, R505	Potentiometer	20K	Spectrol 53-1-1-203
R506	Resistor	100K, ±10%, 1/4W	
R507	Resistor	6.8K, ±10%, 1/4W	
R508	Resistor	5.1K, ±5%, 1/4W	
R509	Resistor	2K, ±5%, 1/4W	
R510	Resistor	390 ohm, ±10%, 1/4W	
Q501	Transistor	NPN, Silicon	2N4124
Q502	Transistor	PNP, Silicon	2N4126
5. HV SUPPLY, 10606-A04			
C101	Capacitor	.1 µF, ±10%, 80V	Sprague 192P1049R8
C102	Capacitor	3.3 µF, ±20%, 10V	Kemet K3R3C10
C103	Capacitor	120 µF, ±20%, 10V	Kemet K120C10
CR101	Diode	2500 PIV	Varo VA-25 or equal
CR102	Diode		1N34A
CR103	Diode	Dual Junction	Motorola MZ2361
Q101	Transistor		Fairchild 2N4234
Q102, Q106	Transistor		Motorola 2N4124
Q103	Transistor		Motorola 2N4126
Q104, Q105	Transistor	FET, Matched Pair	Eberline 10519-A04
R101	Resistor	470 ±10%, 1/4W	
R103	Resistor	1.2K, ±10%, 1/4W	
R104	Resistor	680 ±10%, 1/4W	
R105	Resistor	3.9K, ±10%, 1/4W	
R106, R107, R108	Resistor	22 Mego, ±10%, 1/4W	
R109	Resistor	120K, ±5%, 1/4W	
R110	Resistor	2.2 Mego, ±10%	
R111	Resistor	68K, ±5%, 1/4W	
R112	Resistor	10 Mego, ±10%, 1/4W	
R113	Resistor	10K, ±10%, 1/4W	
R114	Resistor	33K, ±5%, 1/4W	
R115	Resistor	22 Mego, ±10%, 1/8W	
T101	Transformer Assy.		Eberline 10931-00

REF DESIG	PART	DESCRIPTION	MFR AND PART NO
6. SCALER			
A301, A302, A303, A304, A305, A306	Integrated Circuit	BCD, Up/Down Counter, Plastic DIP	AMD #U6M93L6059X or equal
A307, A308, A309, A310, A311, A312	Integrated Circuit	LED Readout	H.P. 5082-7300 Intensity D or E
A313	Integrated Circuit	Quad 2 Input NOR Gate, type 7402, Plastic DIP	T. I. SN7402N or equal
A314	Integrated Circuit	Dual 2-wide AND-OR-INVERT Gate, low power, type 74L51, Plastic DIP	T. I. SN74L51N or equal
C301	Capacitor	.68 µF, 35V	CS13
C302, C303	Capacitor	56 µF, 6V	CS13
DS301	Diode	Light Emitting	Monsanto MV5021
R301, R302, R303, R304	Resistor	3K, ±5%, 1/4W	
R305	Resistor	680 ohm, ±10%, 1/4W	
7. TIMER			
A201	Integrated Circuit	Quad 2 Input NOR Gate	RCA CD4001AE
A202, A203	Integrated Circuit	Divide-by-12 Counter, Type 7492, DIP, 70°C	Fairchild U6A749259X or equal
A204, A205, A206, A207	Integrated Circuit	Decade Counter, Type 7490, DIP, 70°C	Fairchild U6A749059X or equal
A208	Integrated Circuit	Quad 2 Input NAND Gate, Type 7400, DIP, 70°C	Fairchild U6A740059X or equal
C201	Capacitor	.01 µF, 100V	Sprague 192P-10392
C202	Capacitor	.047 µF, ±10%, 100V	Sprague 225P-47391
C203	Capacitor	120 µF, 10V	Type CS13 Case B
Q201, Q202	Transistor	NPN, Silicon	2N4124
R201	Resistor	27K, ±10%, 1/4W	
R202	Resistor	68K, ±10%, 1/4W	
R203	Resistor	12K, ±5%, 1/4W	
R204	Resistor	10K, ±10%, 1/4W	
R205	Potentiometer	100K	Bourns 2299W-1-104
R206	Resistor	120K, ±5%, 1/4W	
R207	Resistor	750K, ±5%, 1/4W	
R208	Resistor	47K, ±10%, 1/4W	
R209	Resistor	4.7K, ±10%, 1/4W	
S201, S202, S203	Switch	2-Pole, 3-Position Slide	Cont. Wirt G-386-PC

SECTION VI
DIAGRAMS

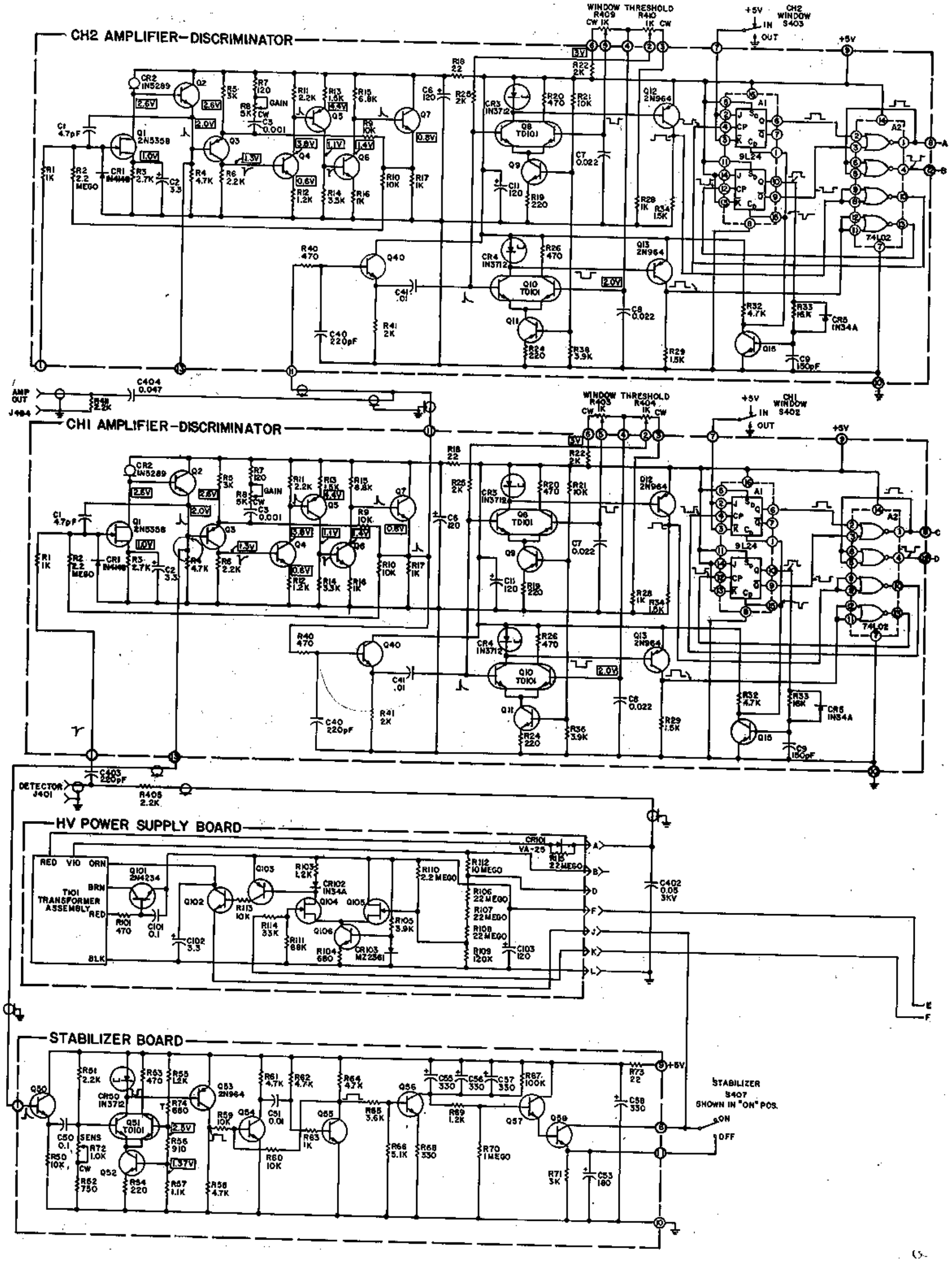
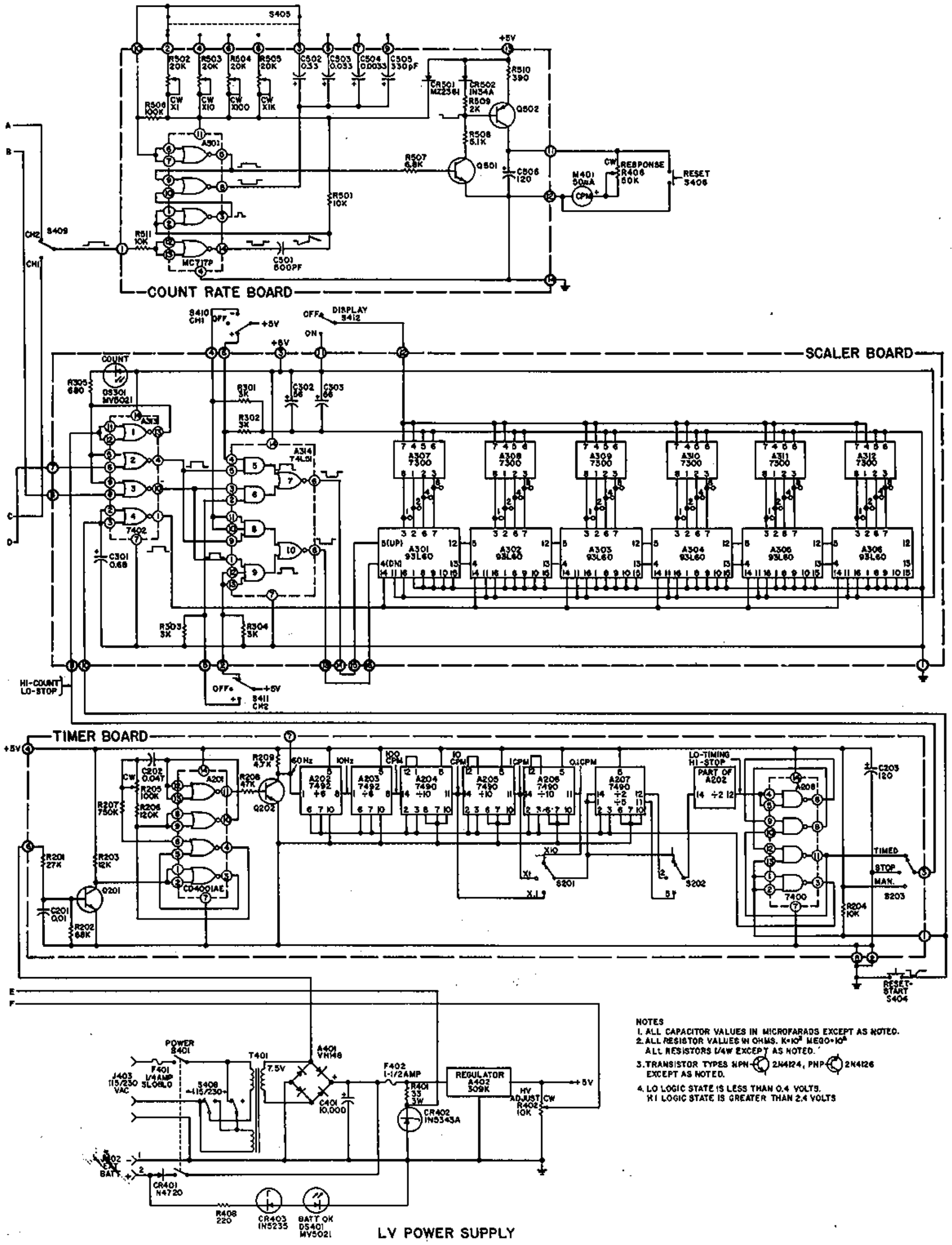


Figure 6-1. General Schematic, Model SAM-2, Sheet 1 of 2



NOTES
1. ALL CAPACITOR VALUES IN MICROFARADS EXCEPT AS NOTED.
2. ALL RESISTOR VALUES IN OHMS. $K=10^3$ $MEGO=10^6$
ALL RESISTORS 1/4W EXCEPT AS NOTED.
3. TRANSISTOR TYPES NPN 2N4124, PNP 2N4126
EXCEPT AS NOTED.
4. LO LOGIC STATE IS LESS THAN 0.4 VOLTS.
HI LOGIC STATE IS GREATER THAN 2.4 VOLTS

Figure 6-1. General Schematic, Model SAM-2, Sheet 2 of 2

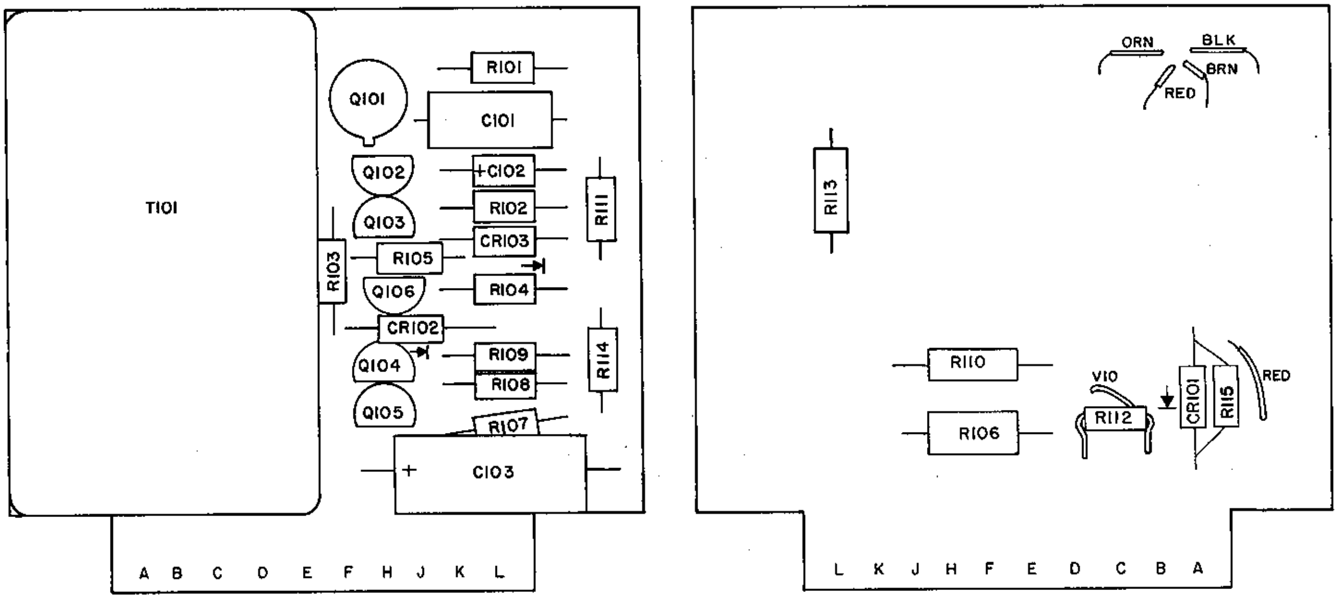


Figure 6-2. Component Layout of High Voltage Board

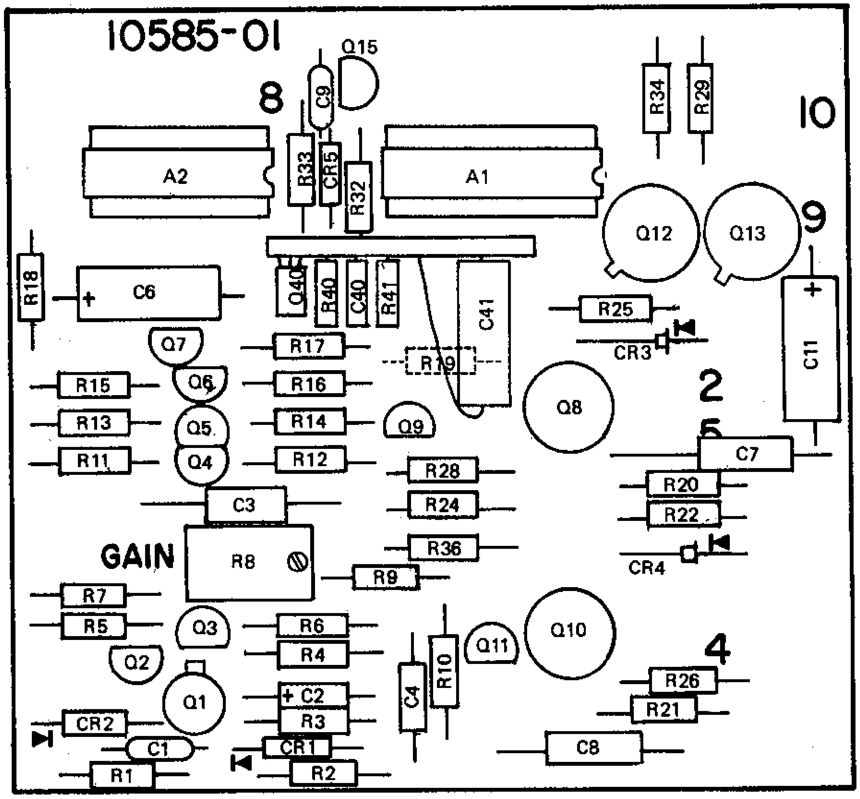


Figure 6-3. Component Layout of Amplifier-Discriminator Board

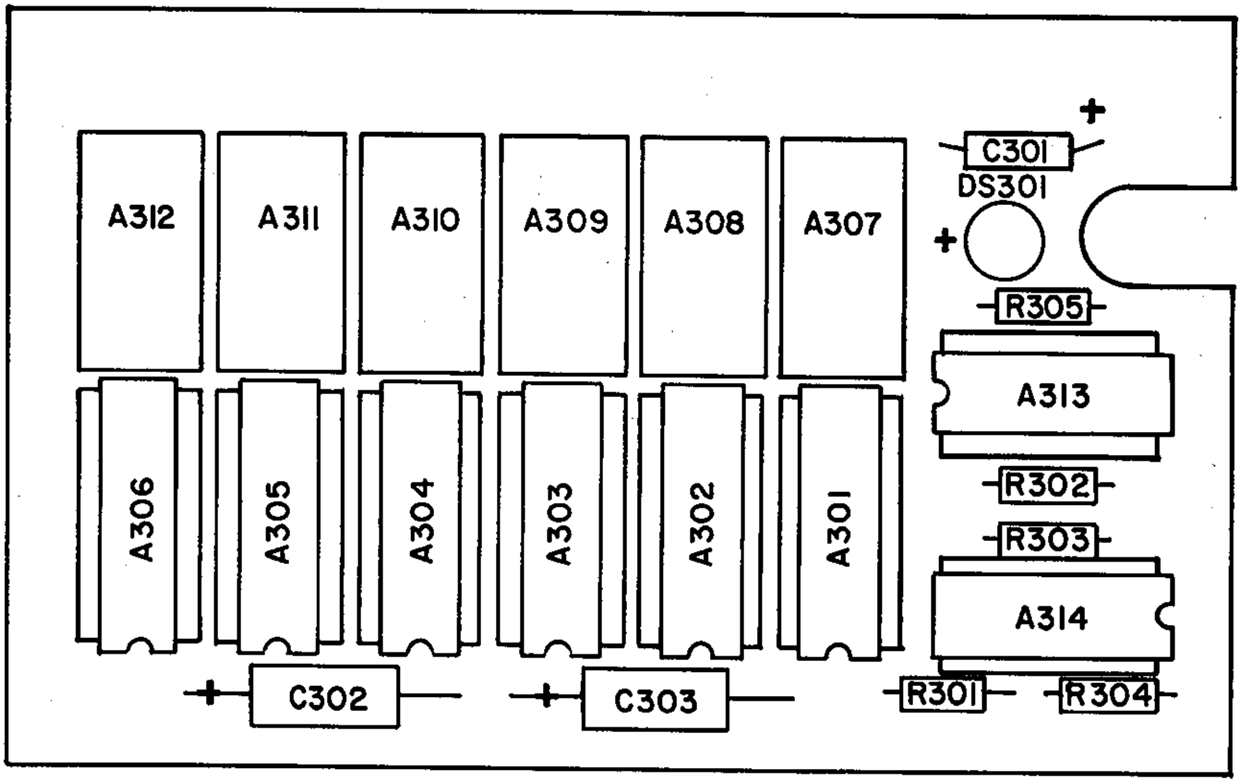


Figure 6-4. Component Layout of Scaler Board

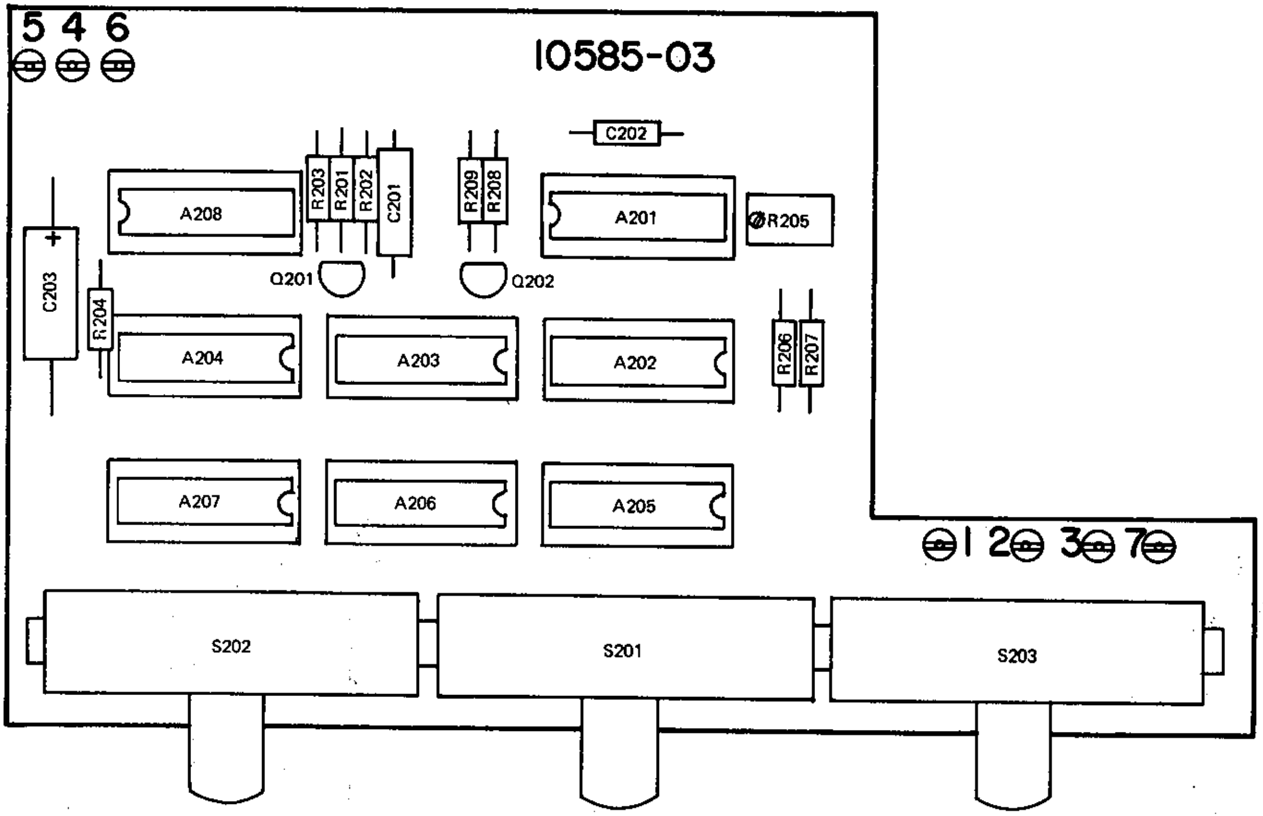


Figure 6-5. Component Layout of Timer Board

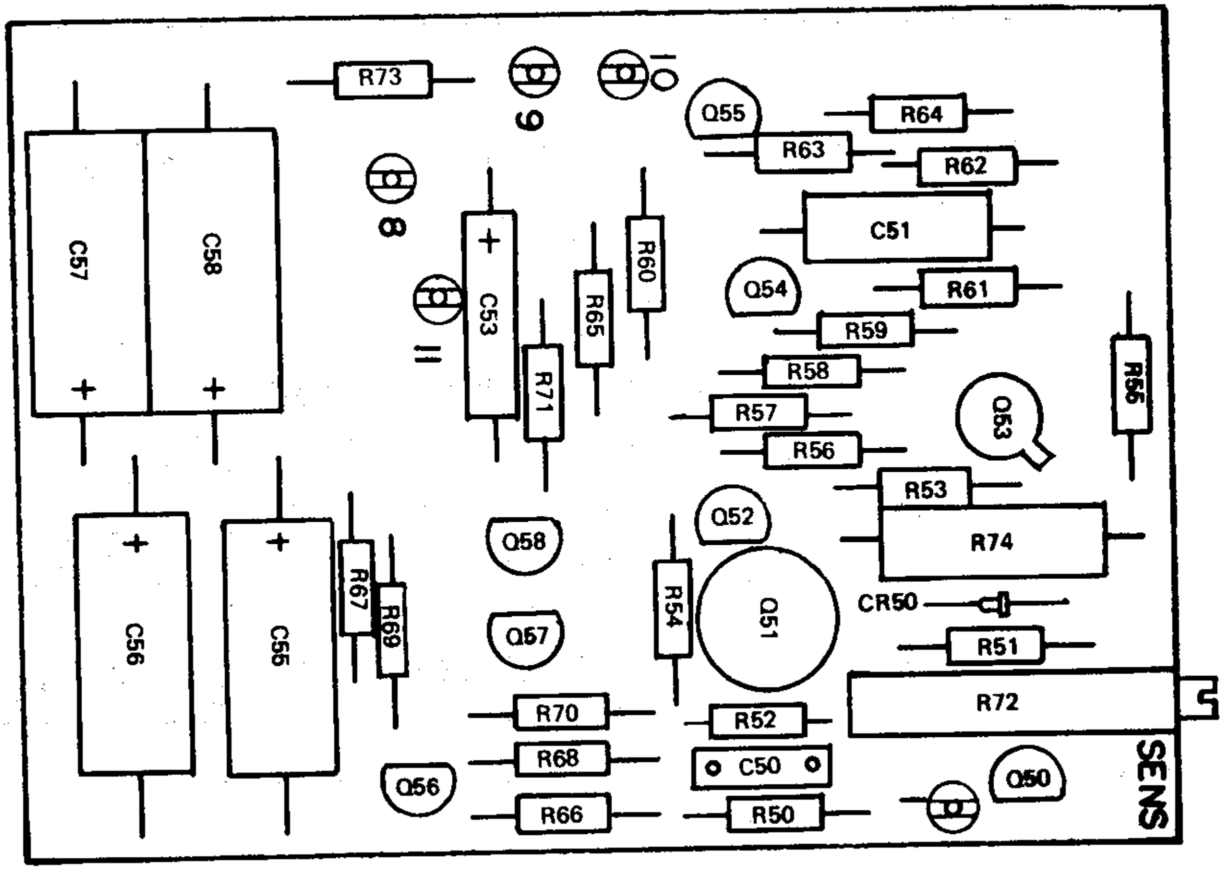


Figure 6-6. Component Layout of Stabilizer Board

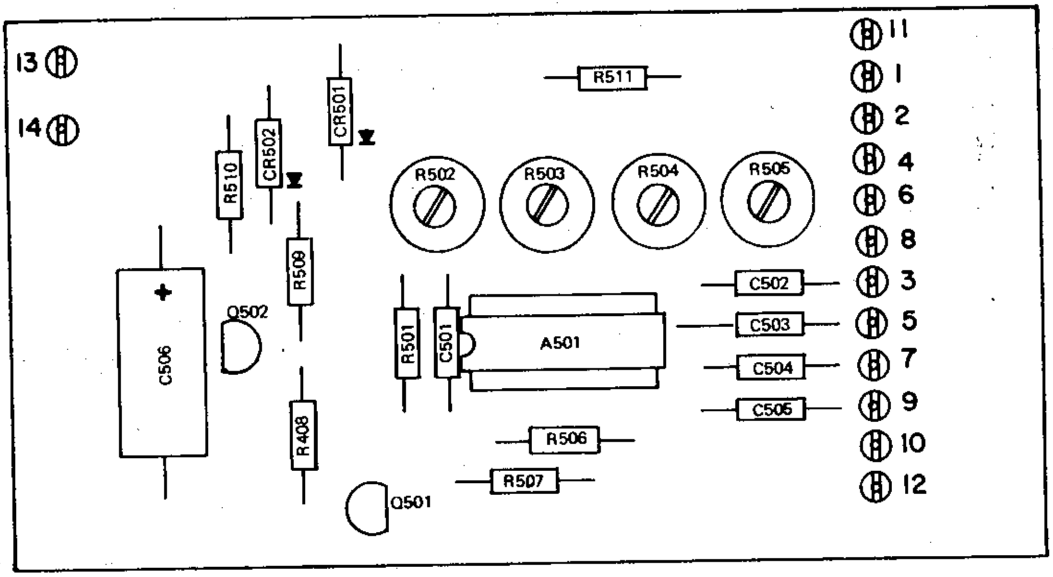


Figure 6-7. Component Layout of Count Rate Board

SECTION VII

APPENDIX

DETECTORS

MODELS RD-19, RD-20, RD-21 AND RD-22

GENERAL DESCRIPTION

Radiation detectors RD-19 thru RD-22 are for use only with an Eberline Stabilized Assay Meter (Model SAM-1 or SAM-2). Each contains a ^{241}Am doped crystal which provides a stabilization signal for the SAM.

Models RD-19 and RD-22 are intended for use with gamma energies above 100 KeV. They differ in the thickness of the crystal (1/2" for the RD-19 and 2" for the RD-22).

Models RD-20 and RD-21 are thin crystal types intended for use with gamma energies below 100 KeV. They differ in the diameter of the crystal and phototube (2" for the RD-20 and 5" for the RD-21).

SPECIFICATIONS

1. Maximum Voltage (all units): 1600 volts.

2. Current Drain (all units): Approximately 10 microamps at 1200V.

3. Connector (all units): Waterproof mating connector is EIC Model CP-1.

4. Crystal

   a. RD-19: 2" diameter x 1/2" thick NaI(Tl) surrounded by 1/16" thick aluminum.

   b. RD-20: 2" diameter x 2 mm thick NaI(Tl) with .001" thick aluminum window.

   c. RD-21: 5" diameter x .063" thick NaI(Tl) with .010 beryllium window.

   d. RD-22: 2" diameter x 2" thick NaI(Tl) surrounded by 1/16" thick aluminum.

5. Resolution (FWHM)

   a. RD-19: Typically 15% for ^{235}U (185 KeV).

   b. RD-20: Typically 25% for ^{241}Am (60 KeV).

   c. RD-21: Typically 22% for ^{241}Am (60 KeV).

   d. RD-22: Typically 13% for ^{131}I (364 KeV).

6. Stabilization Source

   a. Gamma Equivalent Energy: RD-19 and RD-22 – 3.5 ± 0.5 MeV; RD-20 and RD-21 – 1 ± 0.2 MeV.

   b. Count Rate: 1000 ± 200 pulses per second.

7. Size and Weight

   a. RD-19: 2-5/8" diameter x 9-9/16" long, 2-1/4 lbs. (6.65 cm x 24.28 cm, 1.01 Kg).

   b. RD-20: 2-5/8" diameter x 9-9/16" long, 2-1/4 lbs. (6.65 cm x 24.28 cm, 1.01 Kg).

   c. RD-21: 6-1/8" diameter x 12-1/2" long, 9-1/2 lbs. (15.54 cm x 31.75 cm, 4.27 Kg).

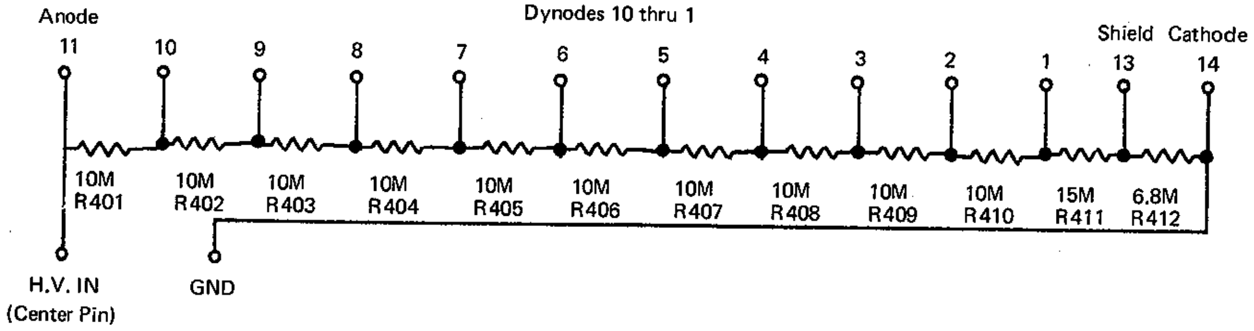
   d. RD-22: 2-5/8" diameter x 11-1/8" long, 3-1/4 lbs. (6.65 cm x 28.24 cm, 1.46 Kg).

OPERATING INSTRUCTIONS

There is no set-up or calibration of the detector itself; all adjustments must be made on the counting instrument (SAM). See the OPERATION section of the SAM manual for proper set-up and adjustment.

SCHEMATIC

The following is a schematic of the phototube base assembly.



SHIELD FOR RD-19 DETECTOR

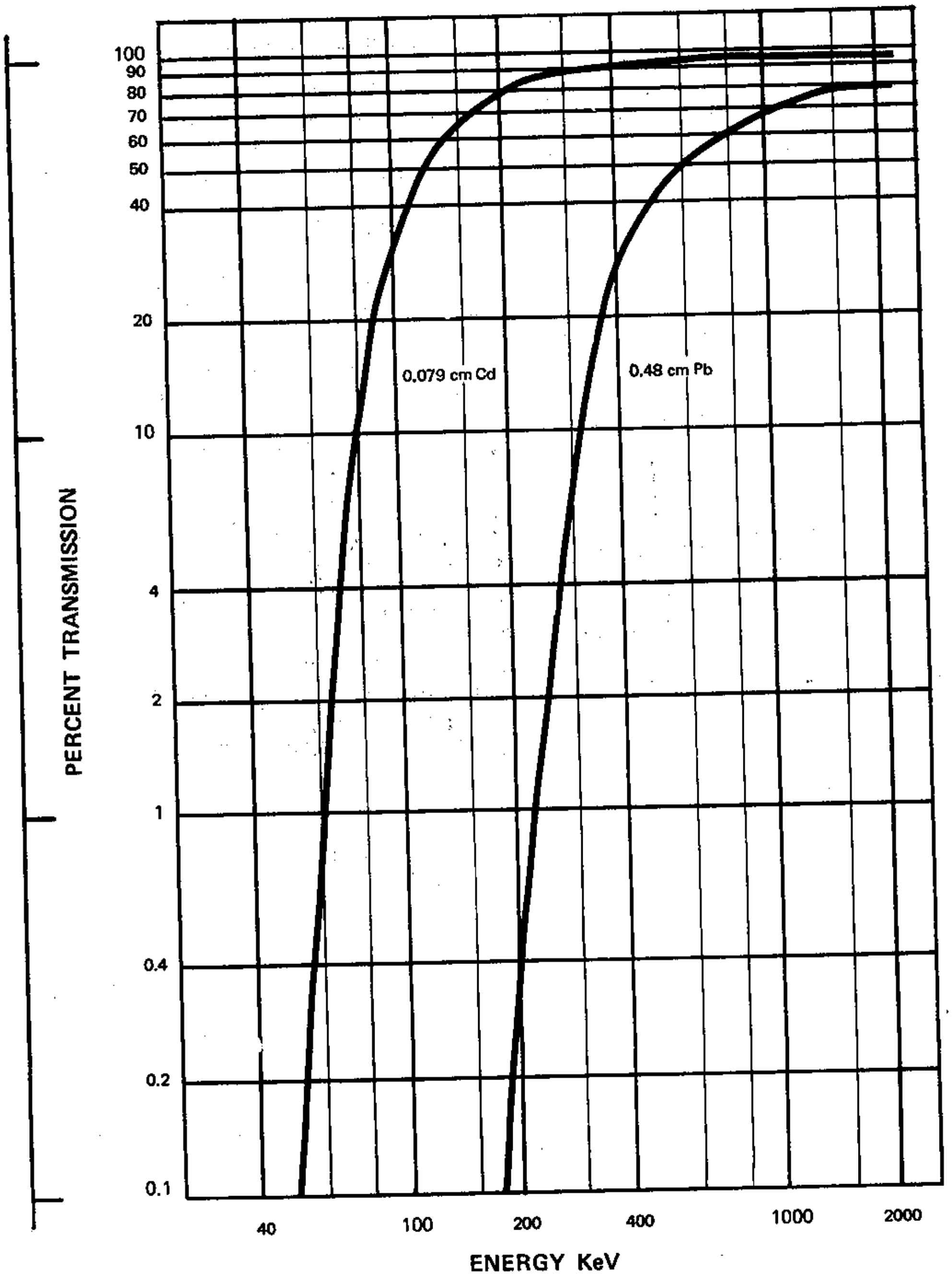
The detector shield (10616-00) is intended for background reduction and collimation when using the RD-19 detector for uranium enrichment measurements.

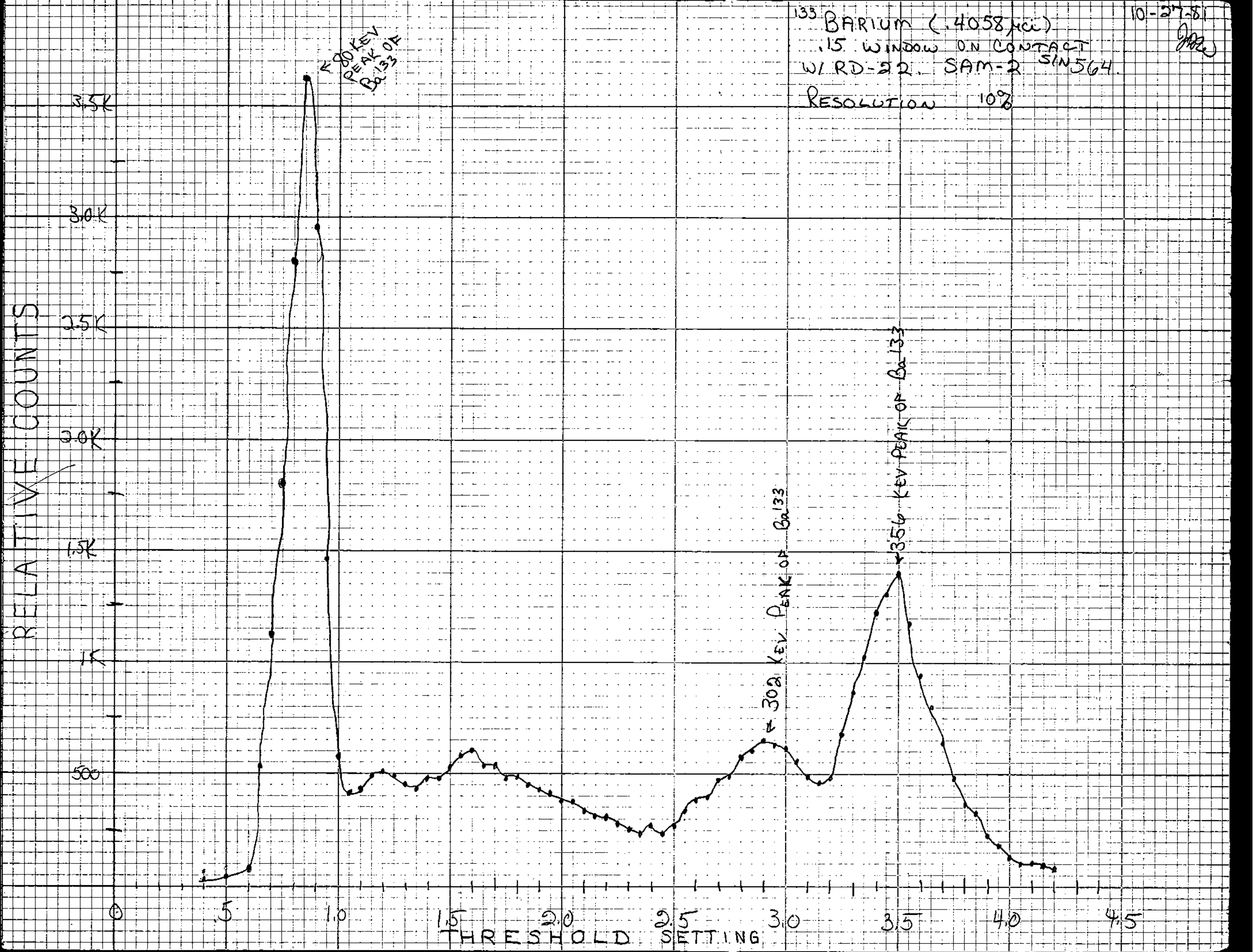
The detector is surrounded by a fixed lead crystal 3/16 inch (0.48 cm) thick. The active end of the shield has a removable 3/16 inch thick lead disc and a removable 1/32 inch (0.079 cm) thick cadmium disc.

The lead disc is supplied with a 1/8" pilot hole in the center. This opening should be enlarged so that the detector can be exposed to a repeatable portion of the material being measured. Larger openings will produce higher count rates and, therefore, smaller statistical errors for a given counting time.

The cadmium disc is intended to attenuate the lower energy emissions. This lowers the total gross count rate which reduces errors due to resolving time and pulse stacking.

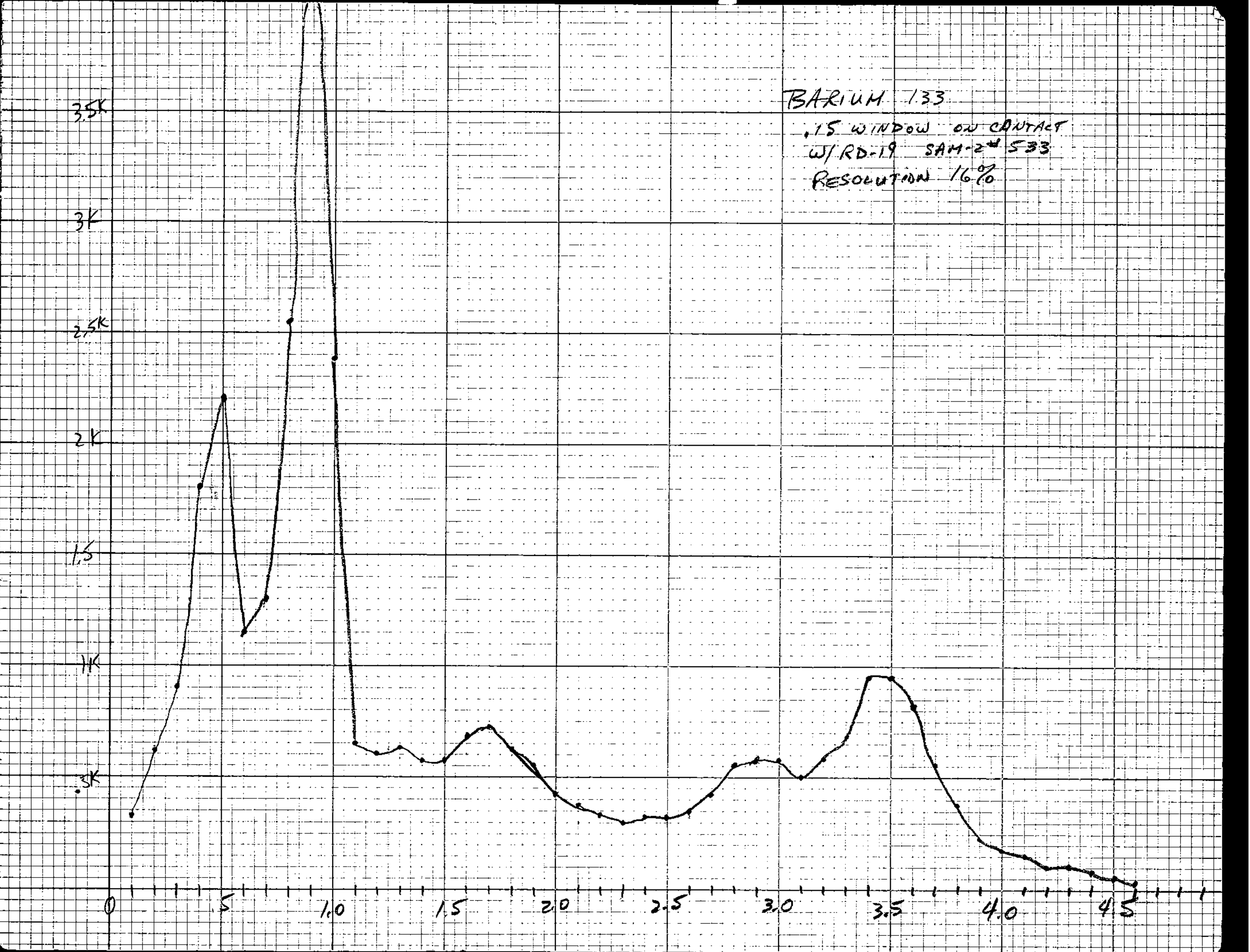
On this sheet is a transmission curve for the two shield materials.





^{133}BARIUM (.4058 µci)
.15 WINDOW ON CONTACT
W/ RD-22. SAM-2 SIN564.
RESOLUTION 10%

10-27-81



BARIUM 133

.15 WINDOW ON CONTACT

W/RD-19 SAM-2 # 533

RESOLUTION 16%

88B

Manual Insert: DIGITAL RATE MULTIPLIER
MODEL DRM-2 (For Miniscaler, Model MS-2)
MODEL DRM-3 (For Miniscaler, Model MS-3)

GENERAL DESCRIPTION

The Digital Rate Multiplier provides a means of scaling the digital readout on the Miniscaler without any loss of statistical accuracy. The count rate from the Amplifier-Discriminator is multiplied by the number set on the control switches. This allows calibration so the scaler will read out in the units of interest.

Any multiplier between 0.001 and 0.999 can be set in. When the IN-OUT switch is in the OUT position, the DRM is bypassed. This gives a direct readout (X1.0 Multiplier).

The DRM-2/DRM-3 is contained in a shallow chassis which attaches directly under the instrument. It includes a decimal select switch to set the decimal point in the display. Zero blanking has been eliminated to show the decimal location at all times.

An example of the use of the Digital Rate Multiplier is as follows:

The instrument is being used with an RD-13 detector. It has been determined that the efficiency of this particular RD-13 is approximately 40% of 4π.

If the DRM is set to the reciprocal of the 4π efficiency divided by the count times, the readout will be in true disintegrations per unit time. The decimal point may then be set to the proper place.

In the example above, if the Miniscaler is reading a sample for 50 minutes, the DRM is set to .500 ($1/.4 \times 1/50 = .05$ but set for .500 for maximum display). The resultant readout on the MS-3 will be the true disintegrations per minutes from the sample when the decimal point is shifted one place. This same method may be employed for other units of time.

THEORY OF OPERATION

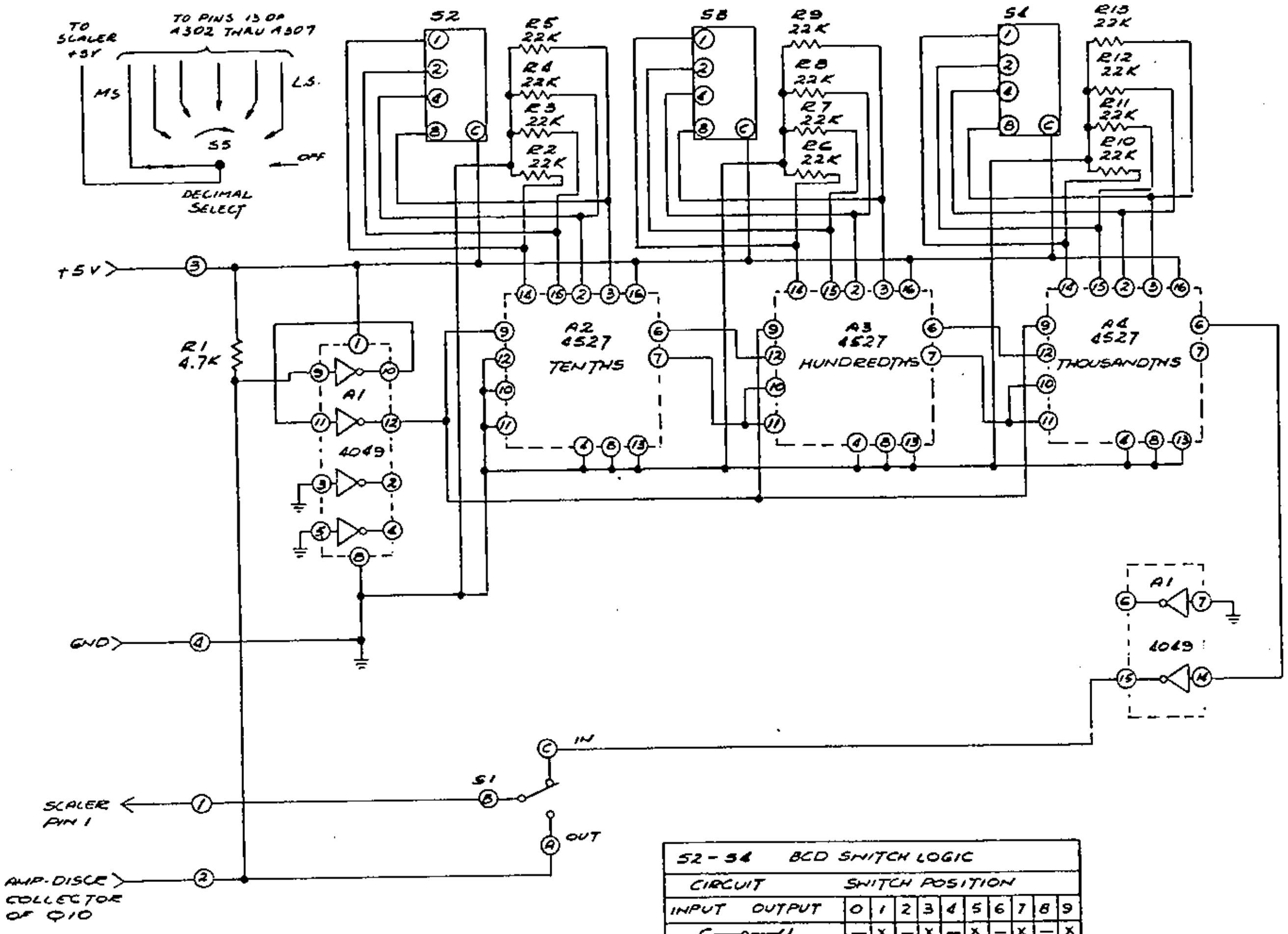
The input signal from the Amplifier-Discriminator connects to the IN-OUT switch and the circuit input. A1 is a hex buffer-inverter which converts signal levels between the TTL logic of the Miniscaler and the CMOS logic of the DRM. From A1, the signal passes thru 3 BCD rate multiplier integrated circuits in cascade (A2, A3 and A4). These circuits produce a number of pulses which is equal to the number of input pulses multiplied by the number set on their control switches. The output signal goes to the IN-OUT switch. The IN-OUT switch controls which signal leaves the DRM chassis to the SAM-2 scaler. When IN, the multiplier signal is used. When OUT, the DRM is bypassed, giving direct data.

eberline P. O. Box 2108, Santa Fe, New Mexico 87501 (505) 471-3232 TWX: 910-985-0678

Ref. No. 1329 Sheet 1 of 2 1-15-80

PARTS LIST

Quantity	Designation	Description
1	A1	RCA CD4049AE Hex Buffer-Inverter
3	A2-A4	Motorola MC14527CP BCD Rate Multiplier
1	R1	Resistor, 4.7K±10%, 1/4W
12	R2-R13	Resistor, 22K±10%, 1/4W
1	S601	Switch, SPST, Alco MTA 106D
3	S2-S4	Switch, BCD Thumbwheel, AMP 435128-1
1	S5	Switch, Rotary, Alco MRB-1-10

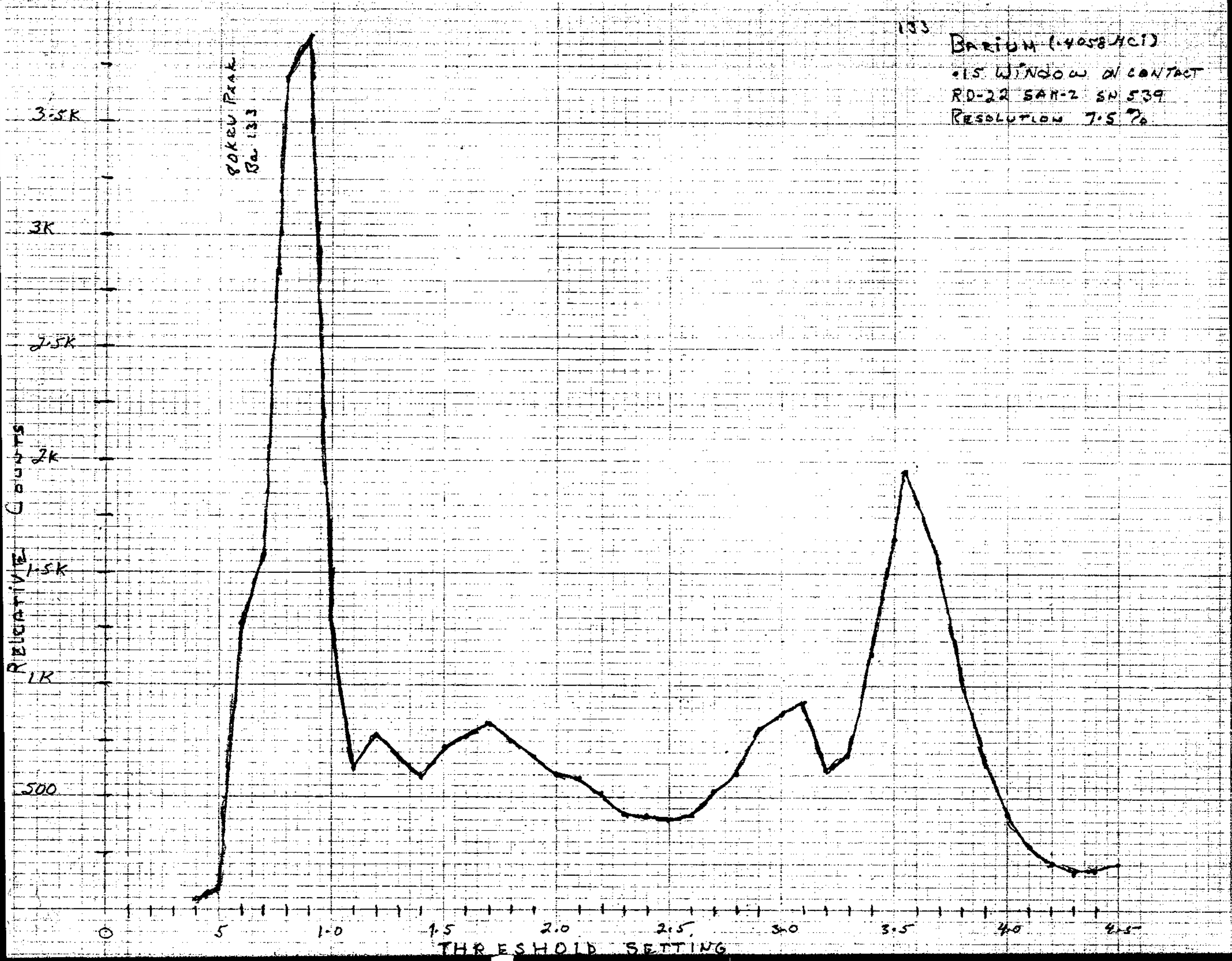


S2 - S4 BCD SWITCH LOGIC

CIRCUIT INPUT	CIRCUIT OUTPUT	0	1	2	3	4	5	6	7	8	9
C	1	—	X	—	X	—	X	—	X	—	X
	2	—	—	X	X	—	—	X	X	—	—
	4	—	—	—	—	X	X	X	X	—	—
	8	—	—	—	—	—	—	—	—	X	X

X = CLOSED CIRCUIT

— = OPEN CIRCUIT


133
BARIUM (.4058 MCI)
.15 WINDOW ON CONTACT
RD-22 SAM-2 SN 539
RESOLUTION 7.5 %
80KEV PEAK
Ba 133
RELATIVE COUNTS
3.5K
3K
2.5K
2K
1.5K
1K
500
0
5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
THRESHOLD SETTING

SECTION VI
DIAGRAMS

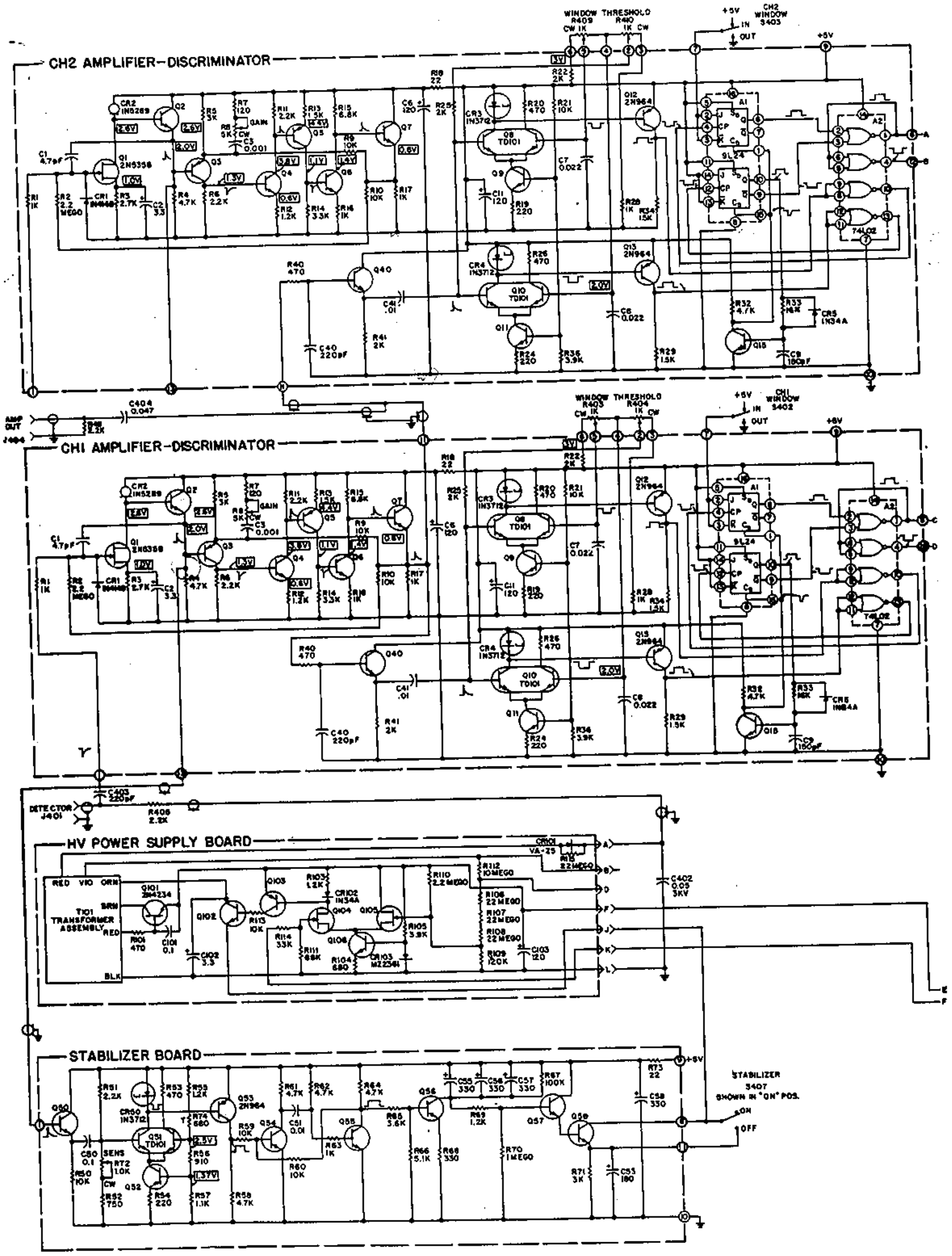


Figure 6-1. General Schematic, Model SAM-2, Sheet 1 of 2

Manual Insert: Digital Rate Multiplier, Model DRM-1

For SAM-2 Stabilized Assay Meter

GENERAL DESCRIPTION

The Digital Rate Multiplier (DRM) provides a means of scaling the digital readout on the SAM-2 without any loss of statistical accuracy. The count rate from each of the single channel analyzers is multiplied by the number set on the control switches for its channel. This allows calibration so the SAM-2 will read out in the units of interest. For instance, in a given set-up for 235U enrichment measurement, the sensitivity may be 20,000 counts per minute per percent enrichment. With a one minute count time and the DRM set at .500, the reading is 10,000 counts per percent enrichment with the statistical accuracy of 20,000 counts. Shifting the decimal over 4 places then gives a reading direct in percent enrichment. Any number between .000 and .999 can be set in, and the IN-OUT switch bypasses the DRM giving a direct readout (1.000 multiplier).

In most set-ups, the window width of Channel Two would be adjusted to give proper background subtraction, so the multiplier of both channels would be set the same. However, if a different window width is desirable for any reason, the multiplier may be adjusted to give the proper subtraction number.

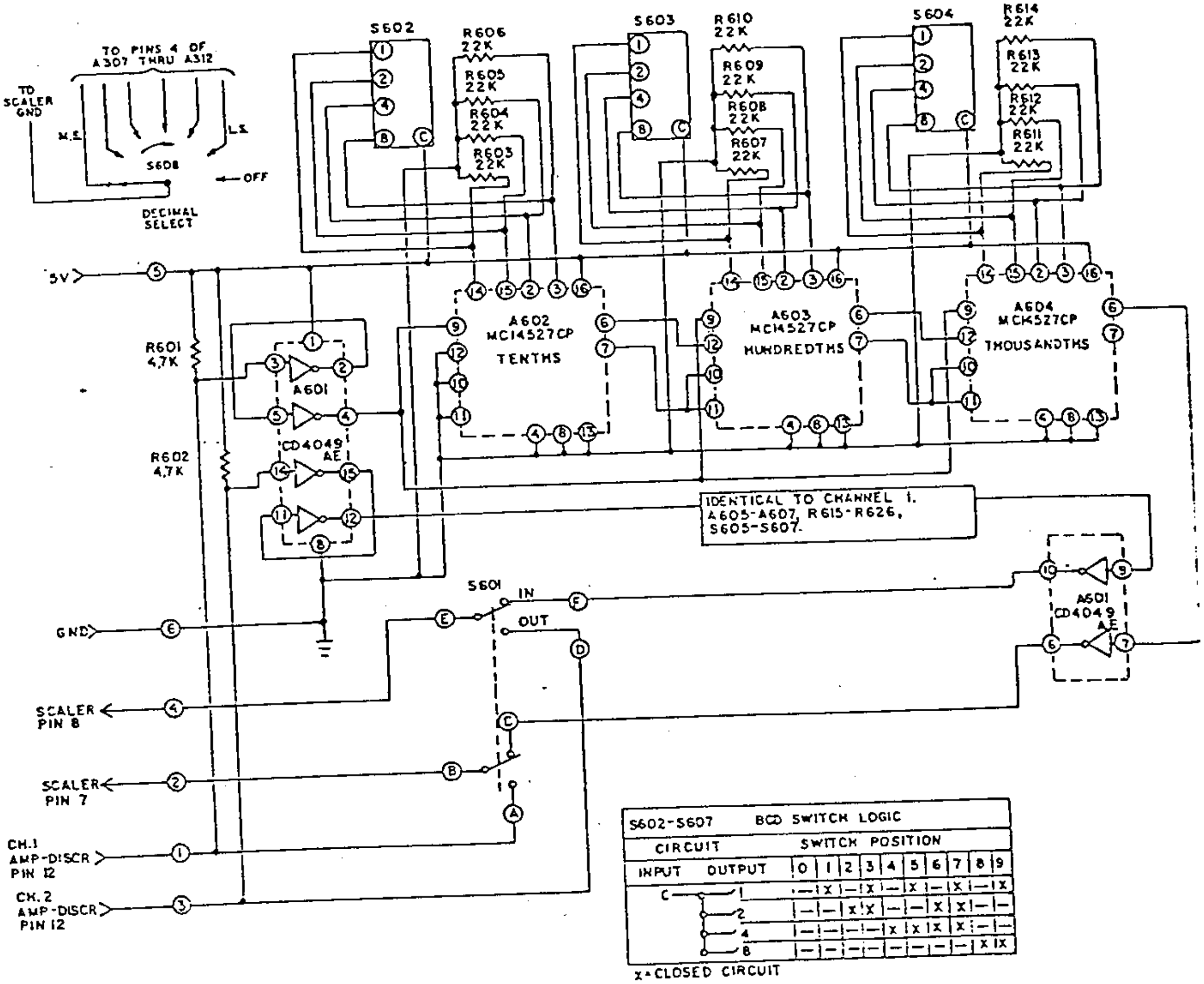
The Decimal Select switch permits the use of any of the six decimal points. No decimals show in the fully clockwise switch position.

The DRM is contained in a shallow chassis which attaches directly under the SAM-2.

THEORY OF OPERATION

Two identical, independent channels are included. The input signal, from the SCA output, connects to the IN-OUT switch and the circuit input. A601 is a hex buffer-inverter which converts signal levels between the TTL logic of the SAM-2 and the COS-MOS logic of the DRM. From A601, the signal passes through 3 BCD rate multiplier integrated circuits in cascade. These circuits output a number of pulses which is equal to the number of input pulses multiplied by the number set on their control switches. The output signal goes to the IN-OUT switch. The IN-OUT switch controls which signal leaves the DRM chassis to the SAM-2 scaler. When IN, the multiplier signal is used and when OUT, the DRM is bypassed giving direct data.

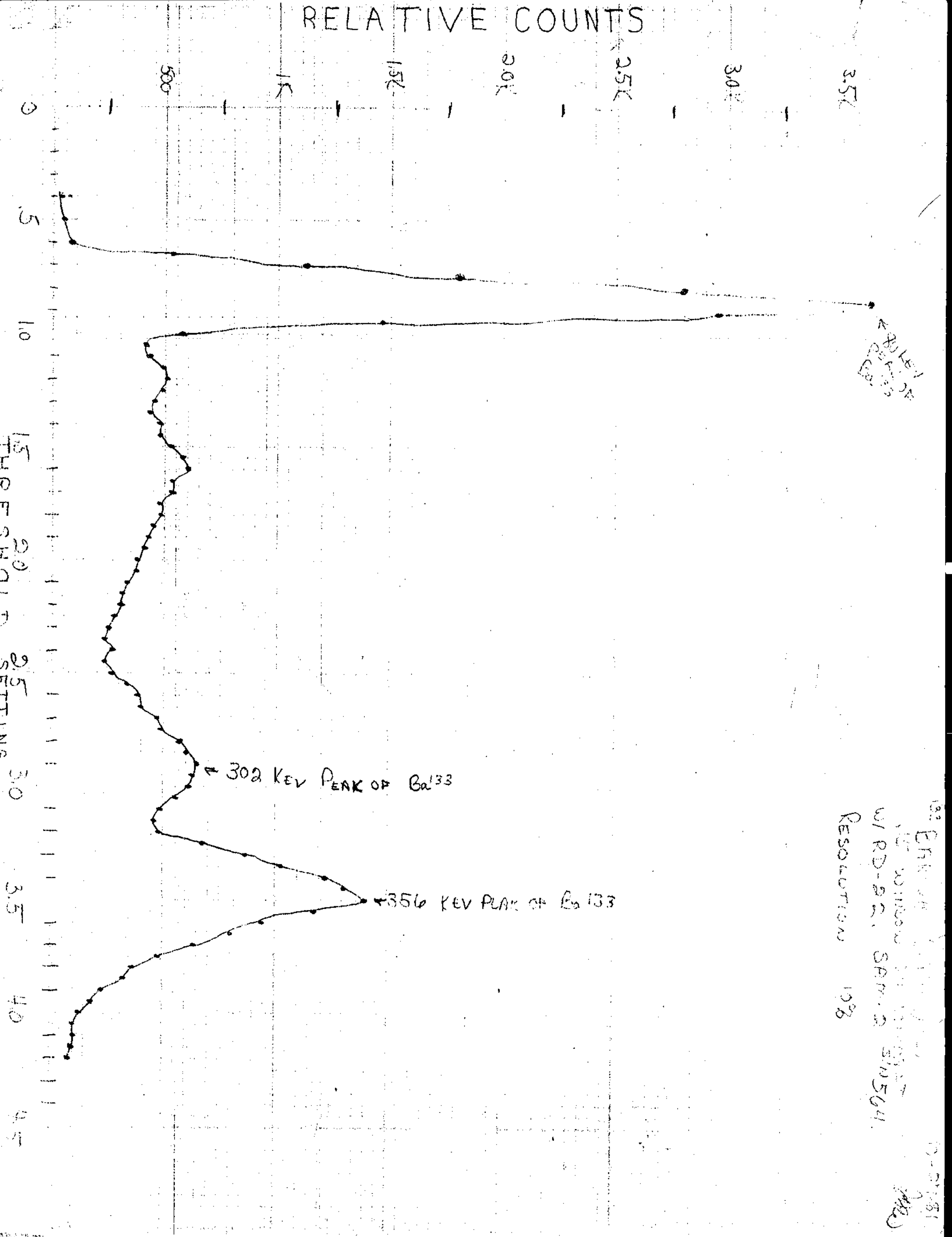
QUANTITY	DESIGNATION	
1	A601	RCA CD4049AE Hex Buffer-Inverter
6	A602-A607	Motorola MC14527CP BCD Rate Multiplier
2	A601, A602	Resistor, 4.7K ± 10%, 1/4W
24	R603-R626	Resistor, 22K ± 10%, 1/4W
1	S601	Switch, DPDT, Alco MST205N
6	S602-S607	Switch, BCD Thumbwheel, AMP 435128-1 SWTW3
1	S608	Switch, Rotary, Alcoswitch MRB-1-10



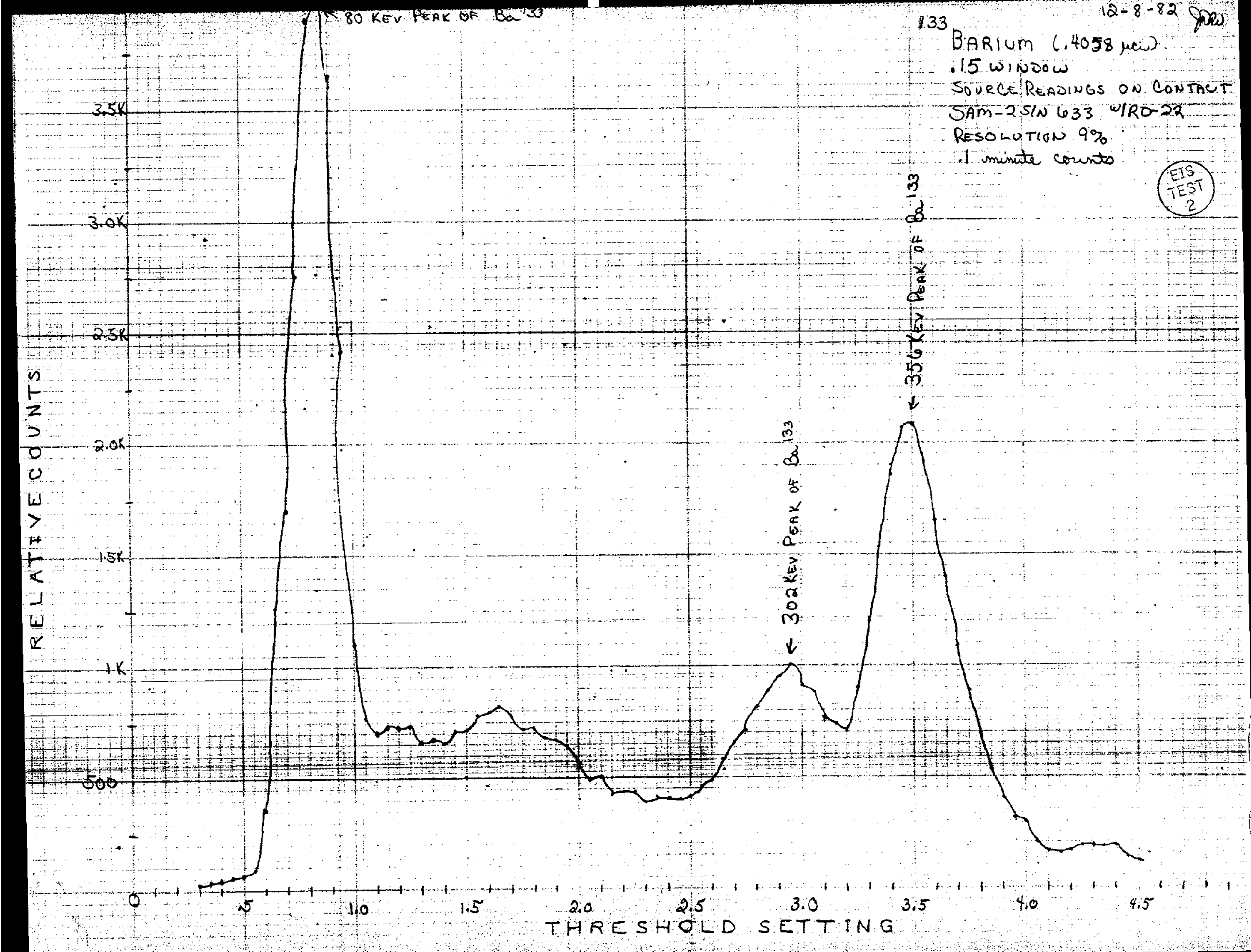
S602-S607	BCD SWITCH LOGIC									
CIRCUIT	SWITCH POSITION									
INPUT OUTPUT	0	1	2	3	4	5	6	7	8	9
C 1	—	X	—	X	—	X	—	X	—	X
2	—	—	X	X	—	—	X	X	—	—
4	—	—	—	—	X	X	X	X	—	—
8	—	—	—	—	—	—	—	—	X	X

X = CLOSED CIRCUIT

— = OPEN CIRCUIT



RELATIVE COUNTS
0
500
1K
1.5K
2.0K
2.5K
3.0K
3.5K
.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
THRESHOLD SETTING
← 81 KEV PEAK OF Ba133
← 302 KEV PEAK OF Ba133
← 356 KEV PEAK OF Ba133
133Ba [illegible]
[illegible]
w/ RD-22, SER. 3 S/N 5641
RESOLUTION 13%



12-8-82 JDW

133 BARIUM (.4058 µci)
.15 WINDOW
SOURCE READINGS ON CONTACT
SAM-2 S/N 633 W/RD-22
RESOLUTION 9%
.1 minute counts

EIS TEST 2